LOAN DOCUMENT

PHOTOGRAPH THIS SHEET

DTIC ACCESSION NUMBER

LEVEL

INVENTORY

0

Demonstration of the Air Force Site . . .

DOCUMENT IDENTIFICATION

Apr 94

DISTRIBUTION STATEMENT A
Approved for Public Release
Distribution Unlimited

DISTRIBUTION STATEMENT

ACCESSION FOR

NTIS GRA&I ☑
DTIC TRAC ☐
UNANNOUNCED ☐
JUSTIFICATION

BY

DISTRIBUTION/

AVAILABILITY CODES

DISTRIBUTION	AVAILABILITY AND/OR SPECIAL	
A-1		

DISTRIBUTION STAMP

DATE ACCESSIONED

DATE RETURNED

20001208 024

DATE RECEIVED IN DTIC

REGISTERED OR CERTIFIED NUMBER

PHOTOGRAPH THIS SHEET AND RETURN TO DTIC-FDAC

HANDLE WITH CARE

DTIC FORM JUN 90 70A

DOCUMENT PROCESSING SHEET

PREVIOUS EDITIONS MAY BE USED UNTIL STOCK IS EXHAUSTED.

LOAN DOCUMENT

Dover

[redacted]

APPLIED
RESEARCH
ASSOCIATES, INC.

Engineering and Applied Science

AQM01-02-0408

DEMONSTRATION OF THE AIR FORCE SITE CHARACTERIZATION AND ANALYSIS PENETROMETER SYSTEM (AFSCAPS) AT DOVER AFB IN SUPPORT OF THE INTRINSIC REMEDIATION (NATURAL ATTENUATION) OPTION

Work performed under
Contract No. F08635-93-C-0080
SETA Subtask 8.01.1

April 1994

ARA Report No. 5868-322
May 4, 1994

by

Martin L. Gildea
Wesley L. Bratton, Ph.D.
James D. Shinn II, PE

of

Applied Research Associates, Inc.
120-A Waterman Road
South Royalton, Vermont 05068

and

Randy St. Germain
Greg D. Gillispie, Ph.D.

of

Dakota Technologies, Inc.
Fargo, North Dakota 58105

DEFENSE TECHNICAL INFORMATION CENTER
REQUEST FOR SCIENTIFIC AND TECHNICAL REPORTS

Title AFCEE Collection

1. Report Availability *(Please check one box)*

☒ This report is available. *Complete sections 2a - 2f.*

☐ This report is not available. *Complete section 3.*

2a. Number of Copies Forwarded 1 each

2b. Forwarding Date July/2000

2c. Distribution Statement *(Please check ONE box)*

DoD Directive 5230.24, "Distribution Statements on Technical Documents," 18 Mar 87, contains seven distribution statements, as described briefly below. Technical documents MUST be assigned a distribution statement.

☒ DISTRIBUTION STATEMENT A: Approved for public release. Distribution is unlimited.

☐ DISTRIBUTION STATEMENT B: Distribution authorized to U.S. Government Agencies only.

☐ DISTRIBUTION STATEMENT C: Distribution authorized to U.S. Government Agencies and their contractors.

☐ DISTRIBUTION STATEMENT D: Distribution authorized to U.S. Department of Defense (DoD) and U.S DoD contractors only.

☐ DISTRIBUTION STATEMENT E: Distribution authorized to U.S. Department of Defense (DoD) components only.

☐ DISTRIBUTION STATEMENT F: Further dissemination only as directed by the controlling DoD office indicated below or by higher authority.

☐ DISTRIBUTION STATEMENT X: Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with DoD Directive 5230.25, Withholding of Unclassified Technical Data from Public Disclosure, 6 Nov 84.

2d. Reason For the Above Distribution Statement *(in accordance with DoD Directive 5230.24)*

2e. Controlling Office HQ AFCEE

2f. Date of Distribution Statement Determination 15 Nov 2000

3. This report is NOT forwarded for the following reasons. *(Please check appropriate box)*

☐ It was previously forwarded to DTIC on .... *(date)* and the AD number is ....

☐ It will be published at a later date. Enter approximate date if known. ....

☐ In accordance with the provisions of DoD Directive 3200.12, the requested document is not supplied because:

....

Print or Type Name Laura Peña

Signature Laura Peña

Telephone 210-536-1431

(For DTIC Use Only) **AQ Number** M01-02-0408

TABLE OF CONTENTS

Section **Page**

INTRODUCTION

The Air Force Civil Engineering Support Agency (AFCESA) retained Applied Research Associates, Inc. (ARA) to demonstrate, test, and evaluate (DT&E) the application of the Air Force Site Characterization and Analysis Penetrometer System (AFSCAPS) in support of the Air Force's intrinsic remediation (natural attenuation) initiatives. One of the key components of the AFSCAPS involves the use of a Nd:YAG dye pumped laser system to induce fluorescence of fuel products as the CPT probe is advanced into the soils. Laser Induced Fluorescence (LIF) has been shown to be useful in identifying petroleum, oil, and lubricant (POL) contamination.

ARA and their subcontractor, Dakota Technologies, Inc. (DTI), in cooperation with Engineering-Science, Inc. (E-S) and the 436 SPTG/CEV office at Dover Air Force Base, jointly conducted an intensive subsurface investigation of soil and groundwater at the SS27/XYZ and D-7 sites located at Dover Air Force Base (AFB), Dover, Delaware. This investigation commenced 11 April 1994 and was completed on 21 April 1994. The dual objectives of this investigation were to:

- adequately assess the subsurface conditions to allow E-S to model the potential for natural attenuation using the Bio-Plume II numerical model, and

- demonstrate the CPT's capabilities to quickly locate and define the areal and vertical extent of the liquid-phase plume using LIF, and to rapidly install monitoring points and collect soil samples to provide additional data necessary to define the dissolved-phase plume.

This data report contains a brief description of the site, data obtained and a brief interpretation of the data. A more detailed analysis of the LIF and analytical laboratory data will be presented in a later report.

BACKGROUND

CPT Capabilities

Historically, cone penetrometry has been employed as an expeditious and effective means of analyzing the lithology of a site by measuring the resistance of different soil types

against the penetrometer probe as it is advanced into the subsurface. ARA has expanded the CPT's capabilities in several ways to allow further definition of the subsurface environment.

The DTI Nd:YAG laser system was integrated into the CPT by ARA and DTI to locate fuel contamination using the LIF response of the soil/fuel mixture. Subsequently, the LIF response can be correlated to the total petroleum hydrocarbon (TPH) concentration present within the soil. To date, the LIF laser system's primary function has been to define the liquid phase plume.

To aid in defining the dissolved-phase plume, ARA has developed a rapid method of installing small-diameter (0.5-inch) monitoring wells. These wells are typically installed based upon the LIF-CPT data and can be installed to any desired depth with a screened interval typically ranging between 1 to 2 meters. Experience has demonstrated that these wells perform well in aquifers where the depth to the potentiometric surface (water table under unconfined conditions) does not exceed the capacity of a vacuum pump (typically about 25 feet below grade).

Collection of soil samples serves several purposes. First it provides a physical specimen with which the CPT data can be correlated. In essence, it allows the observer to look at the CPT cone tip and sleeve stresses combined with the pore water pressure data indicated on the CPT logs and compare it directly with the in situ soils. This allows for accurate interpretation of the CPT logs and subsequent interpretation of the overall site lithology. Secondly, subsequent chemical analysis of the soil samples for total petroleum hydrocarbons (TPH) provides a correlation between LIF data and the in situ TPH concentrations. Finally, additional chemical analysis of the soil samples provides other required data to effectively model the natural attenuation potential of the site using the Bioplume II numerical model.

SITE DESCRIPTION

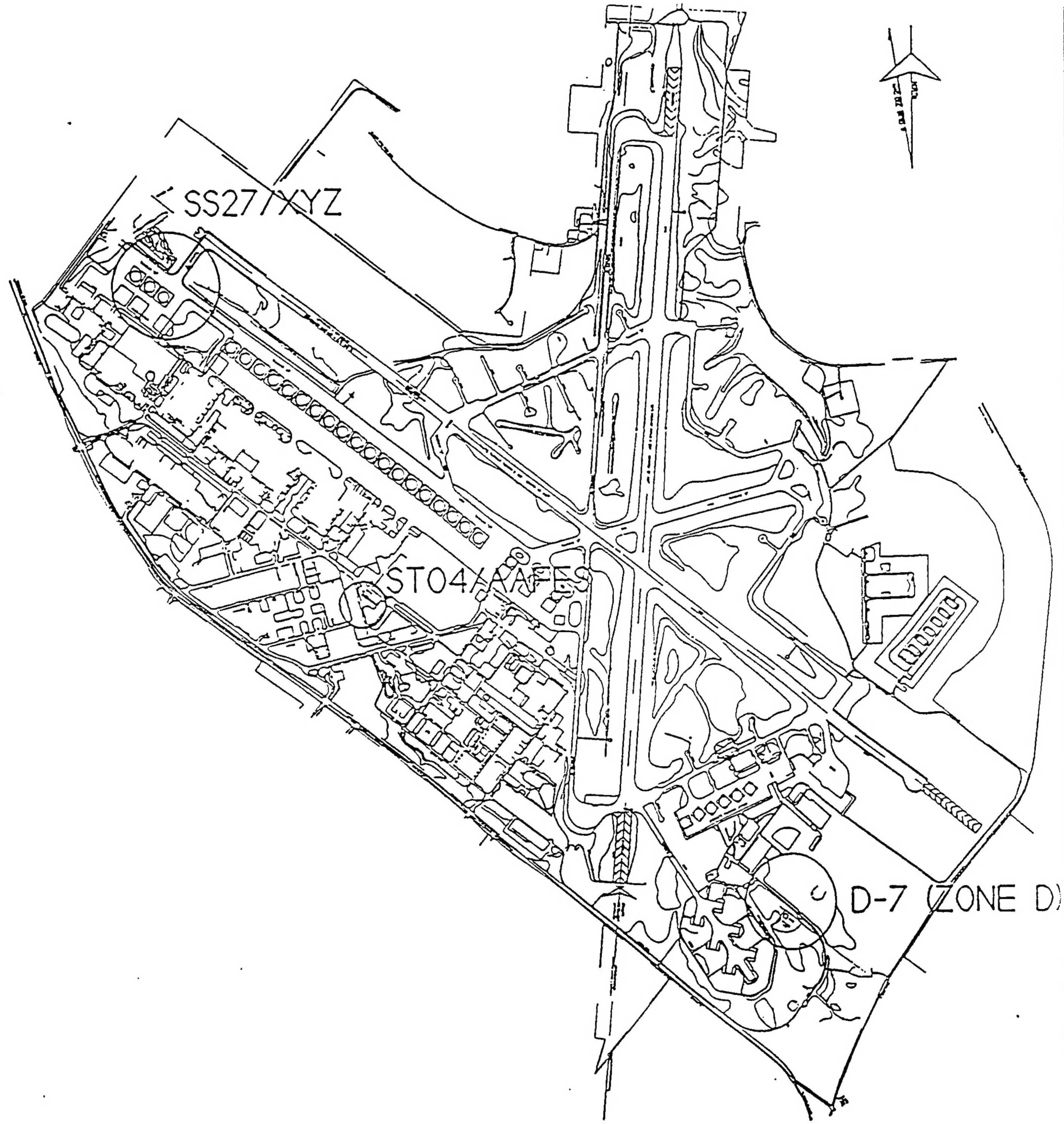
The efforts of this investigation were primarily devoted to the SS27/XYZ site (Figure 1, Site Map). A limited investigation was conducted at the D-7 landfill area that

involved the installation of three nested well pairs (shallow and deep). Because of the limited amount of data collected at this location, it will not be discussed further. The background sections pertaining to the site geology, hydrogeology, and soil and groundwater quality were extracted from the work plan developed by Engineering-Science, Inc. for this site (Ref. 1).

Site Geology and Hydrogeology

Dover AFB is located in the Atlantic Coastal Plain Physiographical Province, a wide wedge-shaped belt of Cretaceous to Recent sedimentary deposits of gravel, sand, silt, clay, limestone, chalk, and marl that dip to the southeast (Ref. 2). Approximately eight sedimentary formations exist under Dover AFB extending as much as 1400 feet below the ground surface. These formations are typified by various lithologies including: sand, gravel, fine to coarse sand, silt, clay, glauconitic sand, glauconitic silts, glauconitic-silty clay, interbedded clay, and variegated clay (Pickett and Benson, 1983). The Columbia Formation, which starts at grade and dominates the near surface geology in Delaware, was deposited under fluvial conditions, forming a broad sheet-like deposit of sand. This unconfined, water-bearing sand layer is characterized by reddish-brown to tan, yellow, or light-gray, poorly sorted coarse-to-medium-grained sand and gravel, with interbedded silt and clay lenses. The thickness of the Columbia aquifer under Dover AFB typically ranges from 25 to over 70 feet.

Site SS27/XYZ is situated on a portion of the Columbia Formation that is characterized by fine-to-medium-grained sand that coarsens into coarse, to very coarse with depth. Laterally discontinuous lenses of clay and gravel are also present. The thickness of the Columbia Formation ranges from 25 to 35 feet under the fueling pads at site SS27/XYZ and groundwater elevations range from approximately 13.9 to 15.6 feet MSL. Estimates of the groundwater flow velocity at site SS27/XYZ were based on pump test data from site D-5, located about 2 miles east, and are approximately 0.29 foot/day, or 106 feet/year. A groundwater divide runs parallel to, and under the NW/SE runway adjacent to site SS27/XYZ. This groundwater divide is apparently the result of extensive runway coverage, which inhibits surface water infiltration of large volumes of fill material used in runway



BASE BOUNDARY

400 0 800 1600

SOURCES: DOVER AFB.

FIGURE 1

SITE MAP

Dover AFB, Delaware

APPLIED RESEARCH ASSOCIATES, INC.

construction. Because of Site SS27's close proximity to the groundwater divide, it is possible that the direction of groundwater flow can switch during seasonal fluctuations in rainfall. However, the average flow of groundwater appears to be in a southwesterly direction with a gradient of 0.0022 foot/foot.

Soil Quality

Characterization of the vadose zone and shallow Columbia aquifer system at site SS27/XYZ has been the objective of several site investigations. To date, four (4) sediment samples have been taken by SAIC (1986, 1989). A soil gas survey completed by SAIC in 1989 (Ref. 3) included 32 measurements across the site. An additional soil gas survey was performed by Dames & Moore in 1993 (Ref. 4) that included a grid of sampling points covering an area approximately 400 by 2,400 feet between the NW/SE runway and the fueling pads. An estimated 75 measurements of soil gas were taken.

The results of the second soil gas study revealed that the majority of petroleum hydrocarbon contamination at site SS27/XYZ is along the fuel lines, though the isocontours for total volatile organic compounds (VOCs) appear to extend beneath the fuel pad. Soil gas study results also indicate that hydrocarbon contamination at the site is high, though not as spatially extensive as reported in previous studies (SAIC, 1989). Oil and grease concentrations in the soil at the site ranged from 2.5 to 65 mg/kg (SAIC, 1986), and soils also contained minor amounts of lead (5 mg/kg).

Groundwater Quality and Chemistry

Previous investigations of site SS27/XYZ detected plumes of benzene (1.4 to 7,000 μg/L), and o-xylene (11 to 870 μg/L), ethylbenzene (1.3 to 2,200 μg/L), toluene (0.3 to 680 μg/L), and o-xylene (11 to 870 μg/L) originating at the JP-4 fuel pipelines extending from Building 950. The most recent investigation of VOCs in the groundwater was conducted by Dames & Moore and HAZWRAP (1993). Results indicate that areas of groundwater contamination coincide with earlier detections of fuel contamination in soil gas.

The highest measured levels of VOC contamination in the groundwater seem to parallel both the runway and the JP-4 fuel lines in a direction extending from the pump stations (Building 950) to the groundwater probe location, GP-3014, approximately 1,000 feet southeast (Figure 2). Samples were collected at depths ranging from 8.5 to 14.5 bgs and analyzed at an on-site laboratory. The highest concentrations of BTEX and total VOCs were detected in samples GP3003, GP3006, GP3007, GP3008, GP3009, GP3014, GP3016, GP3069 and GP3070. Floating product thicknesses of 4, 59, and 38 inches were measured at probes GP3003, GP3007, and GP3008, respectively. Sample GP3009 contained a trace amount of free product. The shape of the contaminant plume does not follow the "tear-drop" pattern extending in the typical direction of groundwater flow, but instead has "halo" shape; edges of the plume stretch toward the NW/SE runway and toward the fueling pads. This "halo" shape is believed to be the result of the groundwater divide adjacent to the site. Contaminants seem to be temporarily contained in the immediate vicinity near the fuel lines, and under fuel pads X, Y, & Z and the taxiways near the site. Background levels of BTEX contamination at wells GP3022, GP3021, and GP3020 (located approximately 1,000 feet southwest of Building 950) were below EPA maximum contaminant levels (MCLs). Detections of chlorinated hydrocarbons were limited to methylene chloride in only three isolated samples: GP3018, (21μg/L), GP3065 (2.9 μg/L), and GP3066 (2.9 μg/L).

RESULTS

During the course of this investigation ARA completed a total of 29 CPT soundings, 26 that included LIF analysis. Figure 3 depicts the approximate locations of these soundings. Based upon this data, 33 successful monitoring wells were installed to various depths to allow collection of groundwater samples for subsequent chemical analyses. In addition, ten (10) soil samples were obtained to provide additional data required for the Bioplume II modeling and to allow correlation with both the CPT and LIF profiles. A summary of soundings completed and respective well completion details and soil sampling intervals is included in Table 1.

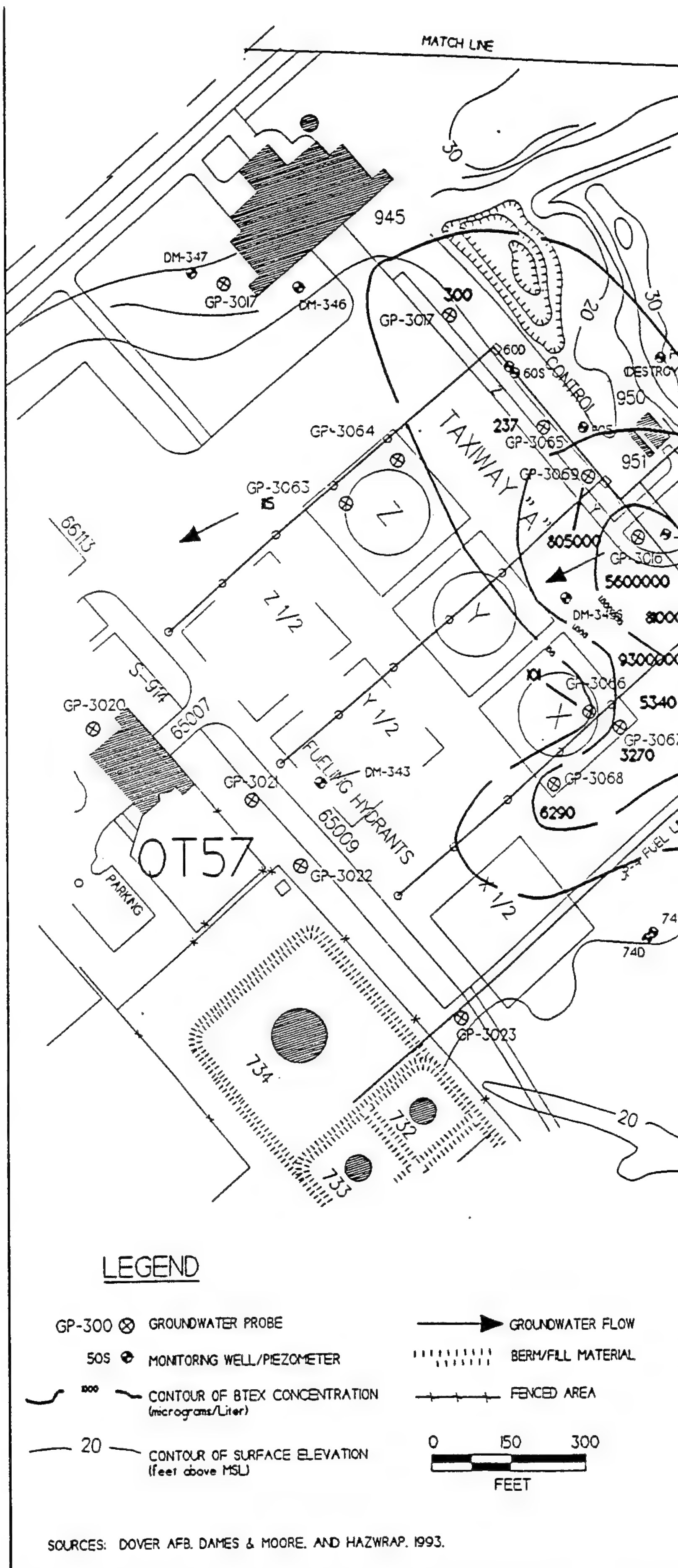


FIGURE 2

BTEX CONCENTRATIONS IN GROUNDWATER AT SITE SS27/XYZ

APPLIED RESEARCH ASSOCIATES, INC.

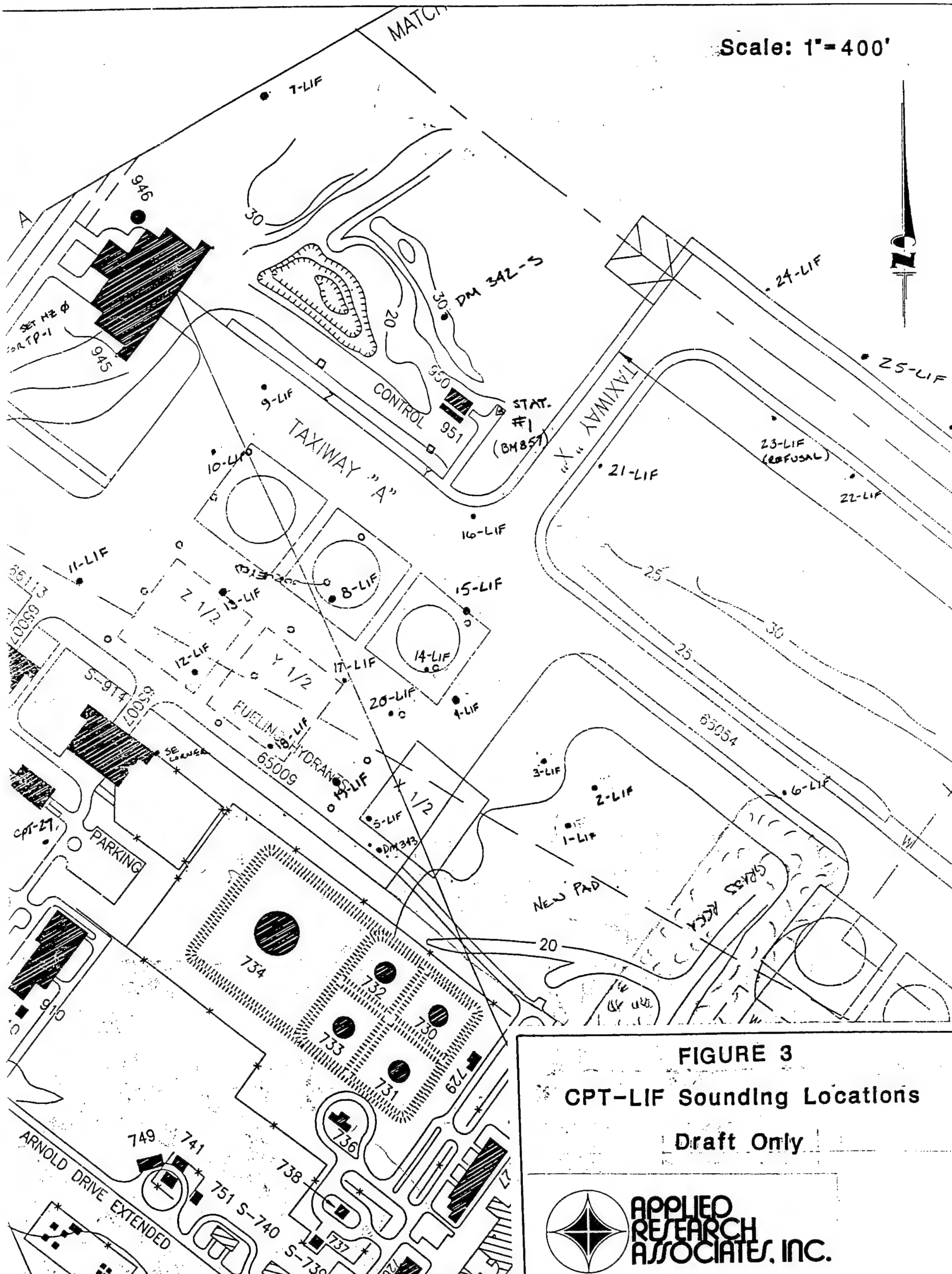


FIGURE 3

CPT-LIF Sounding Locations

Draft Only

APPLIED RESEARCH ASSOCIATES, INC.

Table 1. LIF-CPT Summary.

ID CPT	Soil Unit	MP or SC	Depth Interval	Casing Dia. (in.)	Compt Type	Comments
1	S	MP	13.6-16.9	0.5	P	
2	S	MP	9.6-12.9	0.5	T	
3	S	MP	9.6-12.9	0.5	T	
4	S	MP	13.6-16.9	0.5	T	
5	-	NONE	-	-	-	
6	S	MP	13.2-16.5	0.5	P	
	D	MP	20.5-23.8	0.5	-	Destroyed; Abandoned
7	S	MP	11.6-14.9	0.5	T	
	D	MP	24.8-28.1	0.5	T	
	-	SC	16.0-13.0	-	-	
8	Perched	MP	8.7-12.0	0.5	-	No Yield; Abandoned
	S	MP	13.2-16.5	0.5	P	
	D	MP	24-27.2	0.5	P	
	-	SC	8.0-10.0	-	-	
	-	SC	13.7-15.7	-	-	
9	S	MP	11.9-18.5	0.5	P	
10	S	MP	11.9-18.5	0.5	T	
11	Perched	MP	9.6-12.9	0.5	T	
	S	MP	15.4-18.7	0.5	T	
12	Perched	MP	8.6-11.9	0.5	-	No yield; Abandoned
	S	MP	14.4-17.7	0.5	P	
	D	MP	20.0-23.3	0.5	P	
	-	SC	14.0-16.0	-	-	
13	S	MP	13.9-17.2	0.5	T	
14	S	MP	13.5-16.8	0.5	P	
	WT	MP	7.5-17.5	1.5	-	Wrong depth; Abandoned
	-	SC	7.0-9.0	-	-	No Recovery
	-	SC	13.0-15.0	-	-	
15	S	MP	14.5-17.8	0.5	T	
16	S	MP	10.0-13.3	1.5	-	Wrong depth; Abandoned
	S	MP	10.0-13.3	0.5	P	
	D	MP	20.7-24.0	0.5	P	
	-	SC	7.0-9.0	-	-	

ID CPT	Soil Unit	MP or SC	Depth Interval	Casing Dia. (in.)	Compt Type	Comments
	-	SC	11.0-13.0	-	-	
17	S	MP	15.4-18.7	0.5	T	
18	S	MP	12.0-18.6	0.5	T	
19	Perched	MP	6.7-10.0	1.5	-	No yield; abandoned
	S	MP	12.5-15.8	1.5	-	No yield; abandoned
	S	MP	12.5-15.8	0.5	P	
	D	MP	22.7-26.0	0.5	P	
	-	SC	9.0-11.0	-	-	
	-	SC	15.0-17.0	-	-	
20	S	MP	12.0-15.3	0.5	T	
21	S	MP	11.5-14.0	0.5	T	
22	S	MP	14.5-17.8	0.5	P	
	D	MP	27.0-30.3	0.5	P	
	-	SC	13.0-15.0	-	-	
23	-	-	-	-	-	Refusal at 7 ft.
24	S	MP	12.2-15.5	0.5	-	No yield; abandoned
25	S	MP	17.5-20.8	0.5	P	
26	S	MP	16.5-23.1	0.5	P	
27	S	MP	14.0-17.28	0.5	P	
	D	MP	25.0-28.28	0.5	P	
28	S	MP	17.0-20.28	0.5	P	
29	S	MP	-	0.5	T	
D7CPT01	S	MP	17.5-20.78	0.5	T	
	D	MP	38.22-41.5	0.5	T	
D7CPT02	S	MP	20.0-23.28	0.5	T	
	D	MP	38.22-41.5	0.5	T	
D7CPT03	S	MP	-	0.5	T	
	D	MP	-	0.5	T	

KEY:
S = Shallow
D = Deep
MP = Monitoring Point
SC = Soil Core
T = Temporary
P = Permanent
WT = Water Table

Interpretation of LIF-CPT Profiles

Inspection of the CPT profiles indicate that the overburden soils at the SS27/XYZ site consist of interbedded clays, silts, sands and gravels, and mixtures thereof. This interpretation is in good agreement with findings from previous investigations. The basis for this interpretation is presented below.

Comparison of tip stress, friction ratio and penetration pore pressure profiles are the most important parameters for estimating soil type and stratigraphy from CPT data. The magnitude of the tip resistance is a function of the strength of the soil, with stronger materials having higher tip resistances. Tip resistance also increases as the coarse grained soil content increases, and decreases as the fine grained content increases. The degree of consolidation of the soils can influence tip resistance with both the tip and sleeve stresses increasing as the degree of consolidation increases. Overconsolidation can be caused by previous loading of the soil or desiccation. For a given soil, the tip stress increases with depth due to the increase in geostatic stresses.

The friction ratio is a good indicator of the cohesiveness of the soil, which in turn reflects the fine grained soil content. Soils that are predominantly fine grained have friction ratios generally greater than 2, and sandy soils have ratios of 2 or less. Weak and sensitive clays will have friction ratios of less than 2. The penetration pore pressure response is a function of the soil's shear strength and stiffness, hydraulic conductivity and density. For normally consolidated soils, the penetration pore pressure will be greater than the static pore pressure for clays and silts, and equal to the static pore pressure for clean sands. In overconsolidated, dense soils the pore pressure response can be less than the static pore pressure, especially in those soils that tend to dilate, such as silty sands. The combination of the friction ratio and pore pressure response provides a good identification of the soil stratigraphy. With this basic understanding of the P-CPT data, an analyst can interpret the stratigraphy and soil types visually as described below.

A typical penetration profile from Dover AFB is presented in Figure 4. This profile (XYZCPT14-LIF) was completed to a depth of 22.5 ft and is representative of the geologic conditions at Dover AFB. This profile includes the sleeve stress, tip resistance, friction ratio, penetration pore pressure, and baseline LIF counts measured during the test, along with the soil classification and soil stratigraphy calculated from the data. For location XYZCPT14-LIF, the friction ratio profile is variable, which indicates that the deposits consist of stratified clays, silts and sands, and mixtures thereof down to approximately 13.5 feet. Between 13.5 feet and 19 feet there appears to be a lens of silty sand showing a maximum density at about 16.5 feet. Based on the tip stress, the density decreases uniformly from 16.5 to approximately 19.3 indicating a looser/softer material. From 19.3 to 20.8, the log indicates a stratified sand/clay/silty clay material. This can be clearly seen from the rapid increase in pore water pressure caused by the displacement of the soil by the cone. The pore water pressure increases above the static pressure because the hydraulic conductivity of the fine-grained soil does not allow the pressure to dissipate rapidly. From 20.8 feet to 22.5 the density once again begins to climb, and although not illustrated on this log, previous soundings typically indicated that this is the beginning of a dense gravel lens.

The LIF data accumulates data at a rate of approximately one (1) waveform per second, which correlates to one waveform every two centimeters as the LIF sensor is advanced into the formation. Each waveform consists of 125 data points and, when integrated, yields the LIF intensity value at a particular depth. The LIF data files showed a baseline-shift apparently due to background noise from various sources. To compensate for this shift, the data sets were modified by subtracting out the average of the first five data points in each waveform before integration. This produces a waveform with a zero baseline. To compensate for power shifts from one location to the next, the LIF profile is further modified. The median of the lowest 41 LIF intensity values is subtracted from all LIF values in that profile. This number is called the time base for that profile. The data is subsequently plotted incorporating the above modifications.

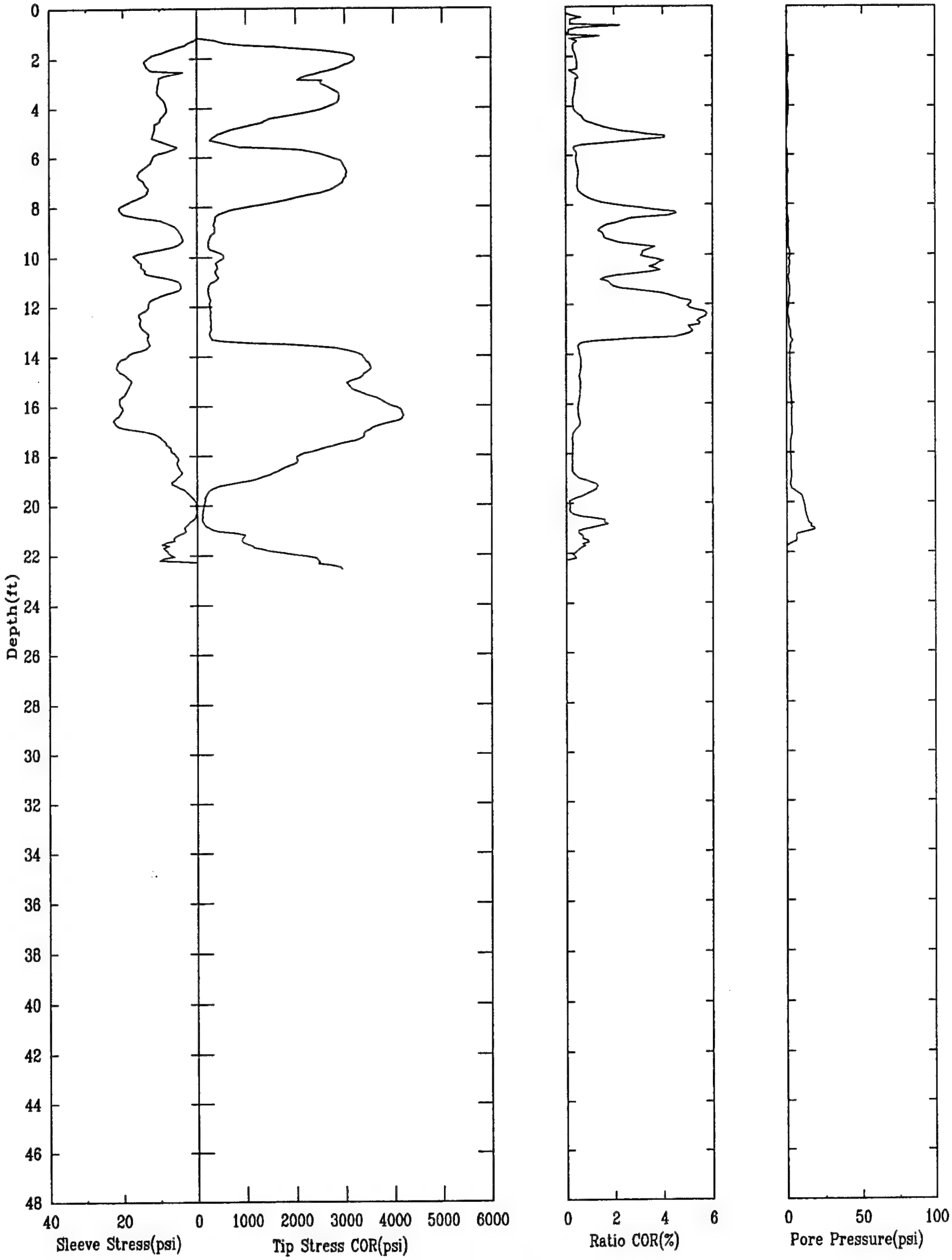


Figure 4. LIF-CPT profiles for XYZCPT-14-LIF.

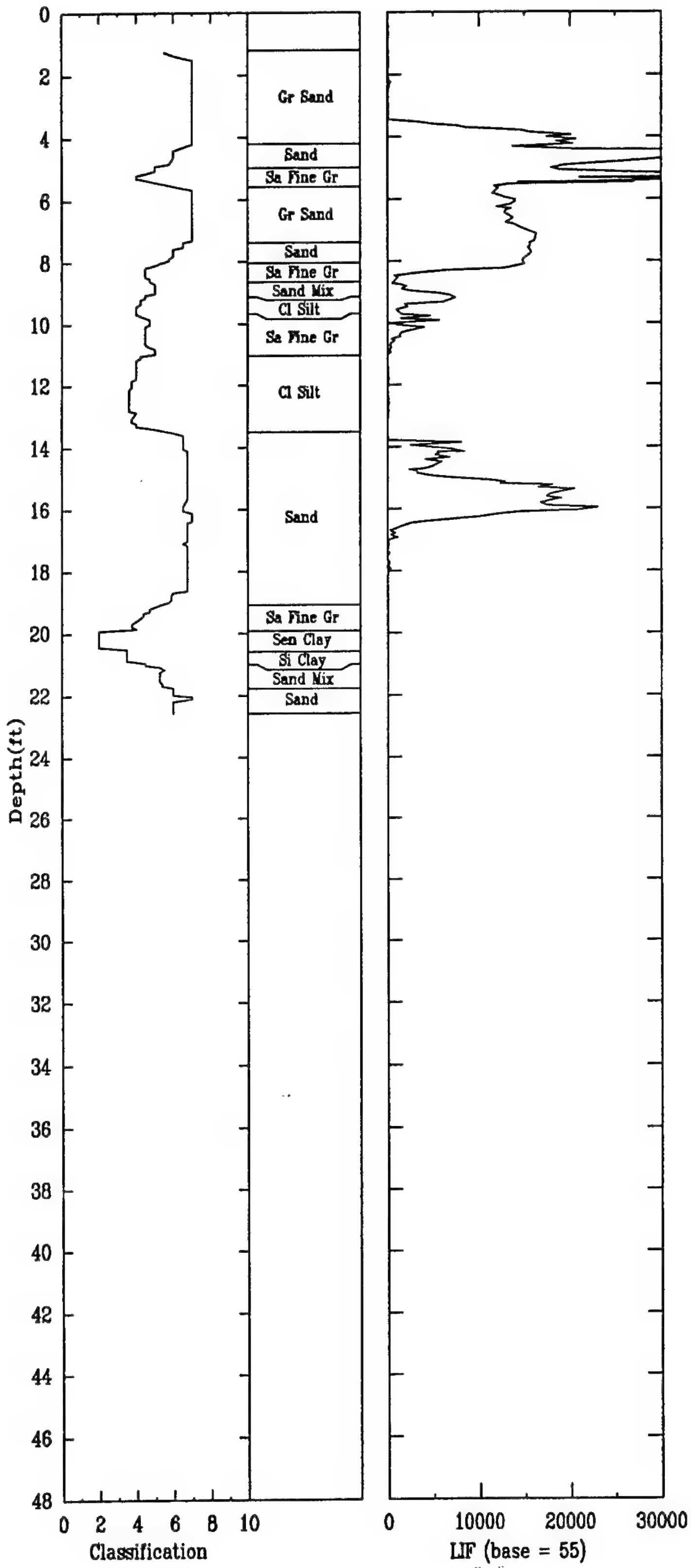


Figure 4. LIF-CPT profiles for XYZCPT-14-LIF (continued).

The LIF profile for XYZCPT14-LIF (Figure 4) shows a significant response beginning at approximately 3.5 feet below ground surface (bgs). Maximum values greater than 30,000 LIF units were noted in the sand seam between 4.3 and 5.5-feet bgs. This response is equivalent to the response of liquid phase JP-4 used to calibrate the laser. The LIF response continues to decrease reaching the baseline value (55 units) at 11 feet bgs. This depth coincides precisely with sand (fine grain)/clayey silt interface. Studies have shown that high clay content can attenuate LIF response that may explain this result. At 13.6 feet bgs the LIF response again shows a significant response, albeit lower than above, increasing to a maximum value at 16 feet bgs, then decreasing to baseline at approximately 17 feet bgs. No further response was noted in this profile.

All of the profiles of the LIF-CPT soundings are included in Appendix A.

CONCLUSIONS

The LIF-CPT proved a useful and efficient tool for conducting a subsurface site investigation at the SS27/ XYZ site located at Dover AFB, in Dover, Delaware. The CPT data accurately described the lithology of the site as interbedded clays, silts, sands, and gravels as well as mixtures thereof. This interpretation closely matches interpretations described by others during previous investigations. The CPT data was used to effectively set monitoring wells and collect soil samples. The LIF data assisted in defining both the horizontal and vertical extent of the liquid phase plume. A complete analytical report assessing all the data collected during the course of this investigation including the groundwater and soil chemical analytical data will be forthcoming.

REFERENCES

1. "Work Plan for an Engineering Evaluation/Cost Analysis in Support of the Intrinsic Remediation (Natural Attenuation) Option," Engineering-Science, Inc., April 1994.

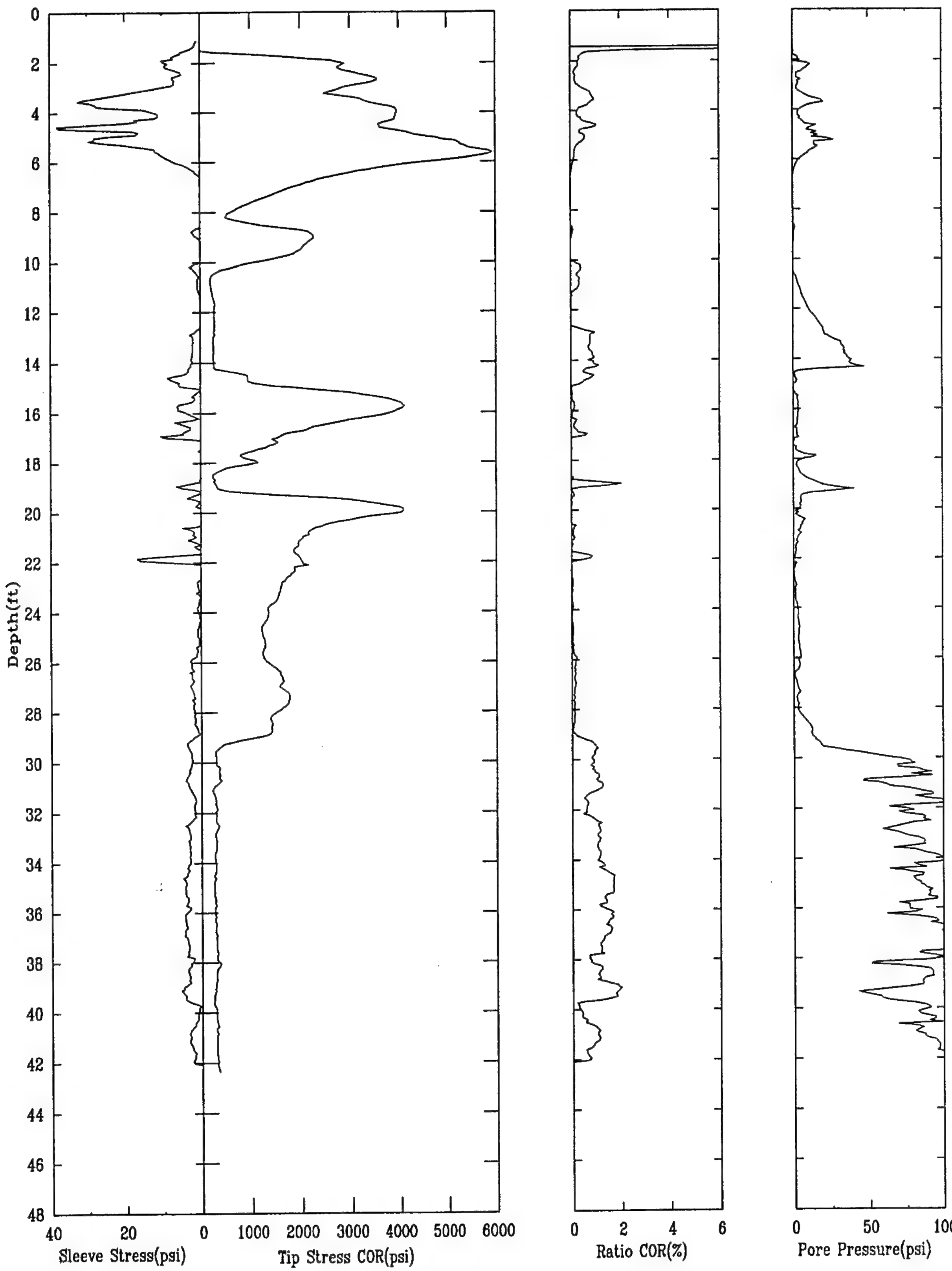
2. Foster, M.D., 1950. "The origin of High Solium Bicarbonate Waters in the Atlantic and Gulf Coastal Plains," Geochimica et Cosmichimica Acta, Vol. 1, pps. 33-48.

3. Science Applications International Corporation (SAIC), 1986. USAF Installation Restoration Program - Dover AFB, Delaware, Phase II - Stage I Confirmation/Quantification.

4. HAZWRAP, 1993b. Ecological Risk Assessment, Phase I: Site Characterization; Dover Air Force Base, Dover, Delaware, submitted by Dames & Moore, February 2, 1993.

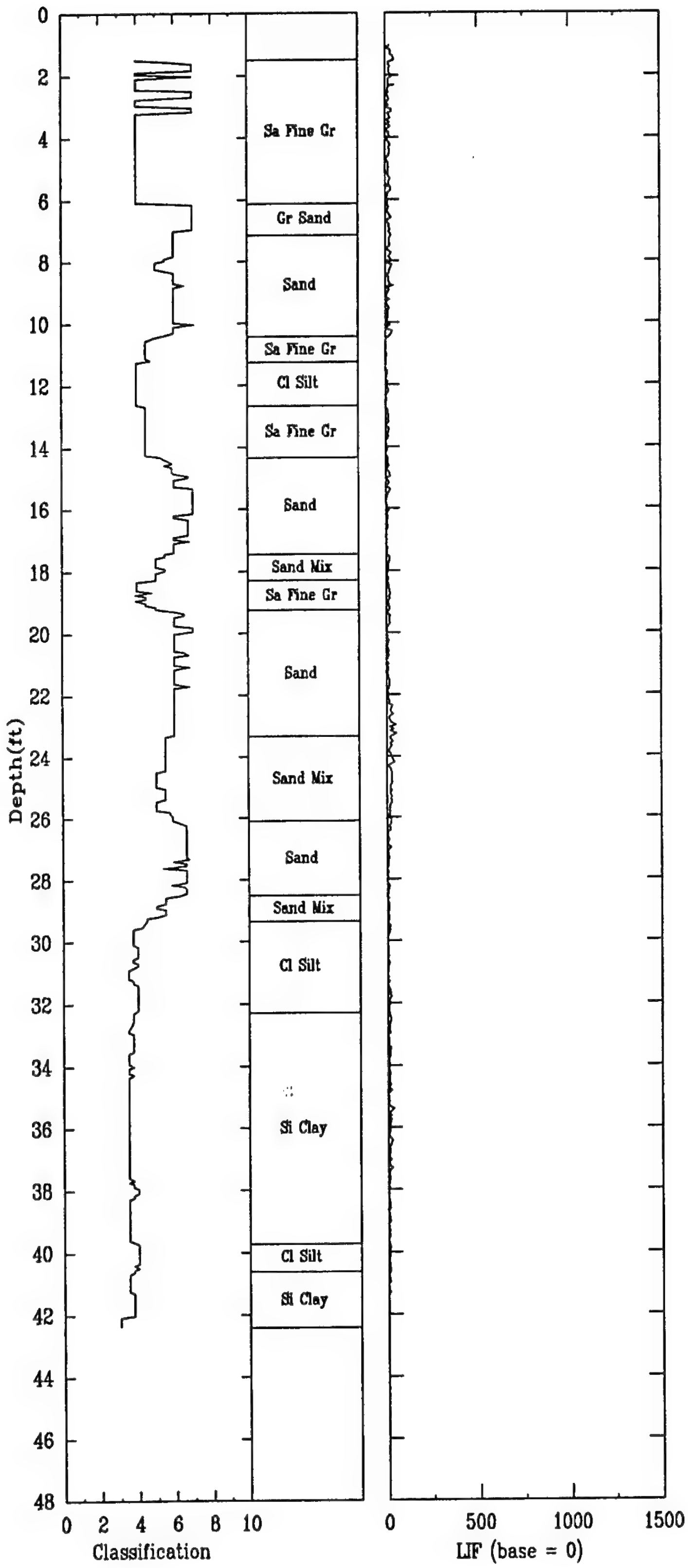
APPENDIX A

Dover Air Force Base



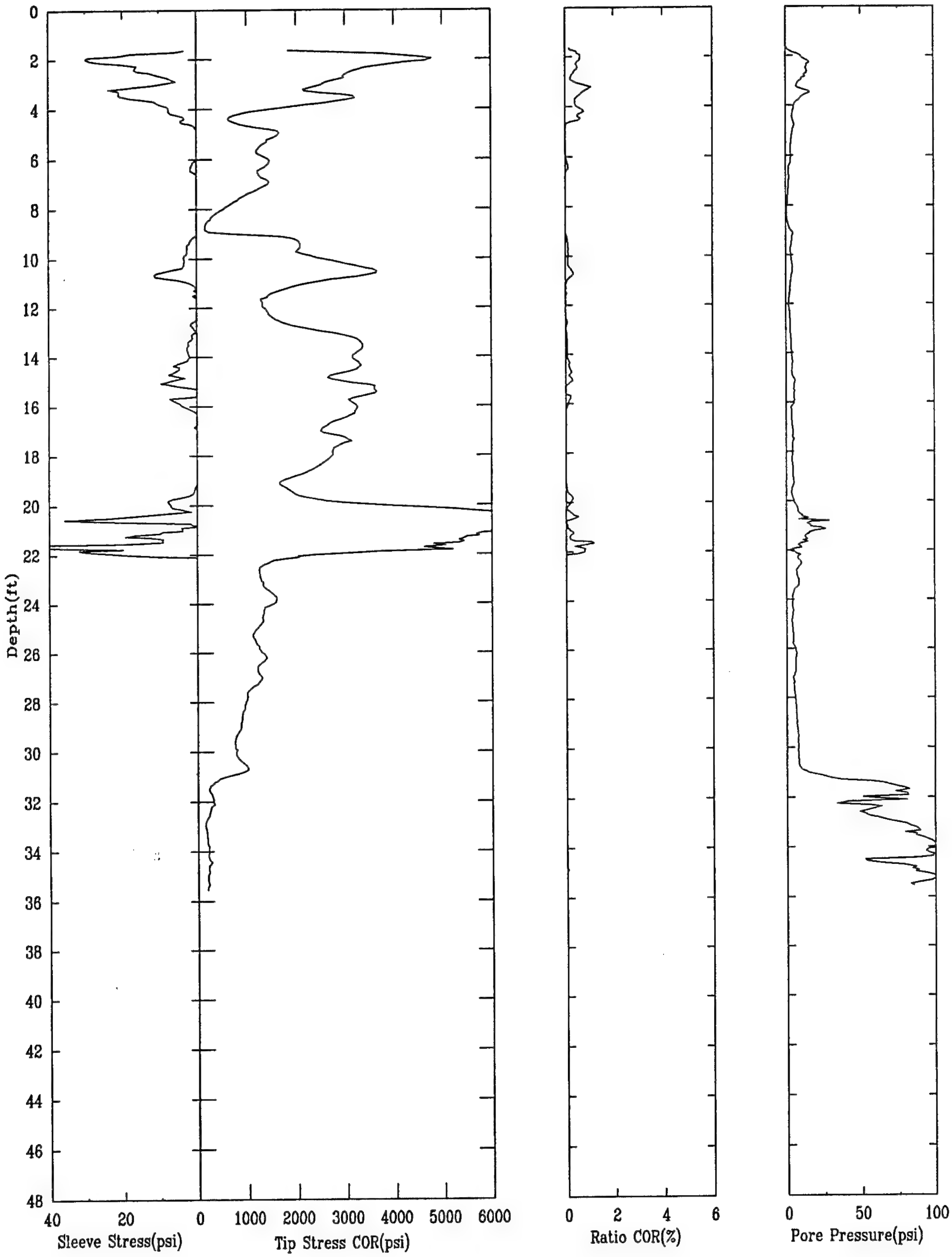
XYZ-CPT-01-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/11/94

Dover Air Force Base



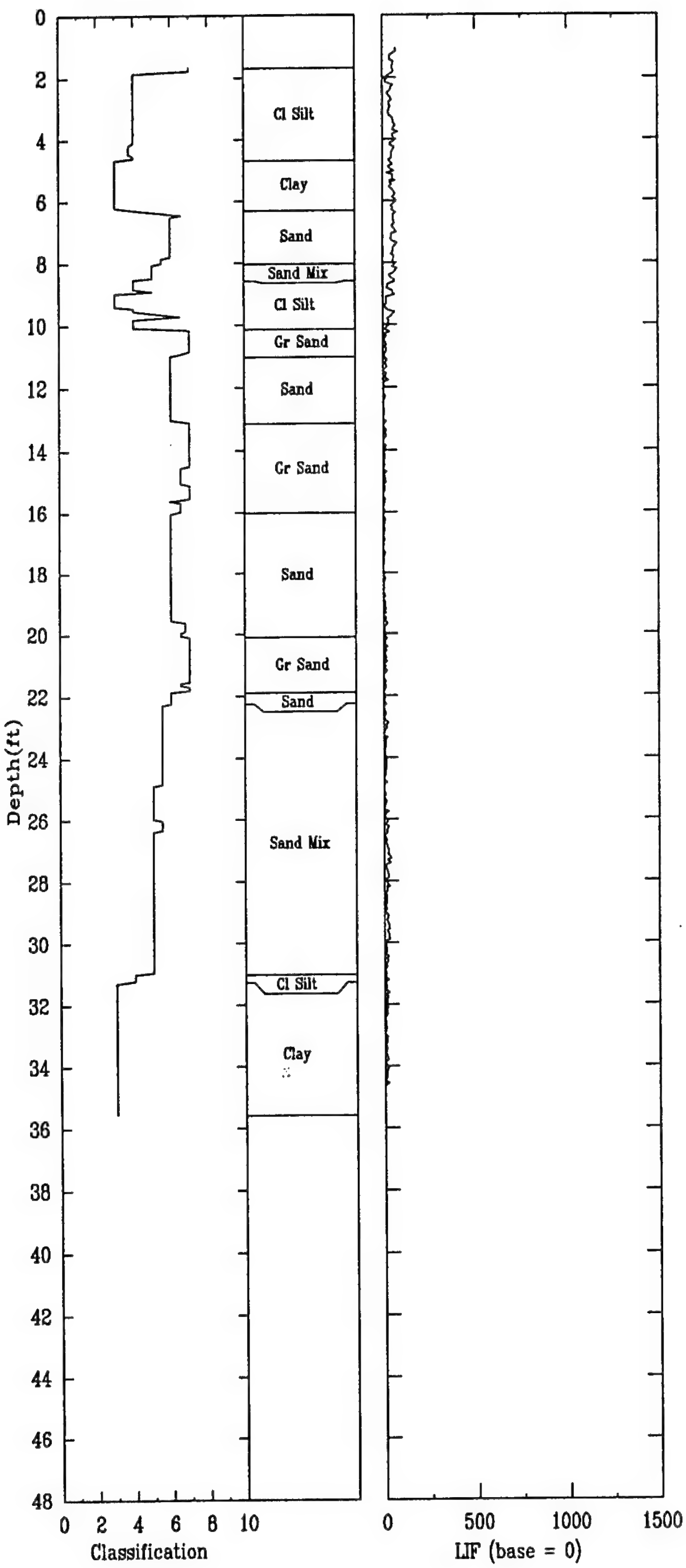
XYZ-CPT-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/11/94

Dover Air Force Base



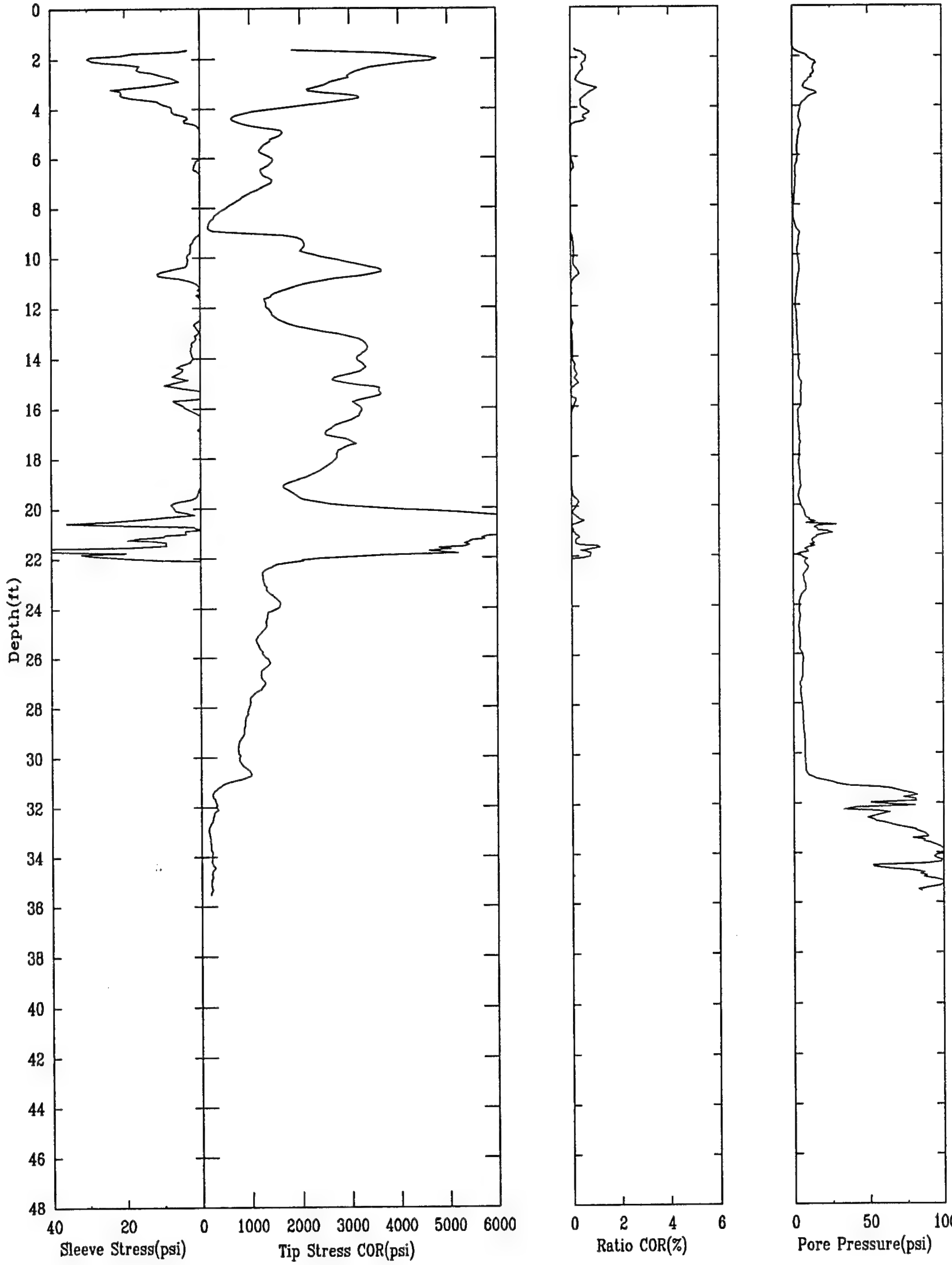
XYZ-CPT-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/11/94

Dover Air Force Base

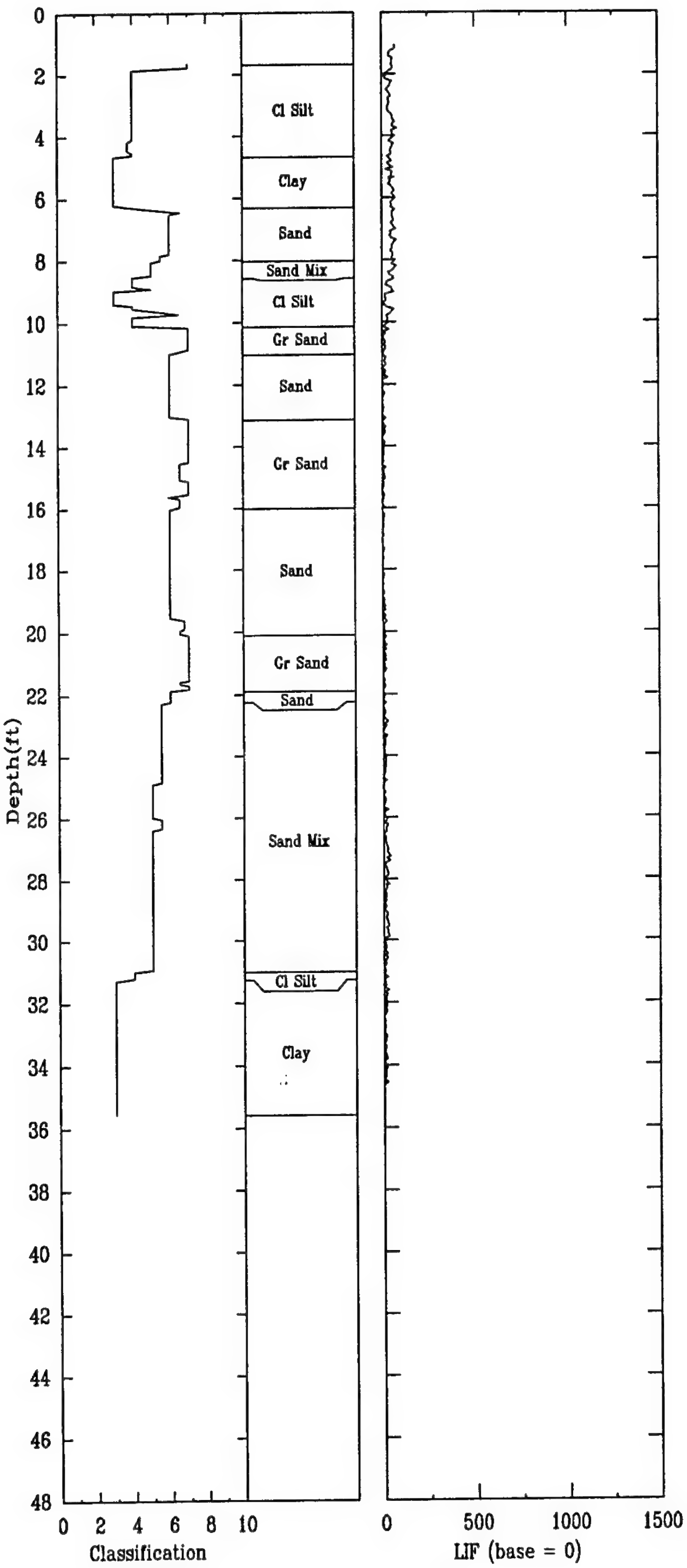


XYZ-CPT-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/11/94

Dover Air Force Base

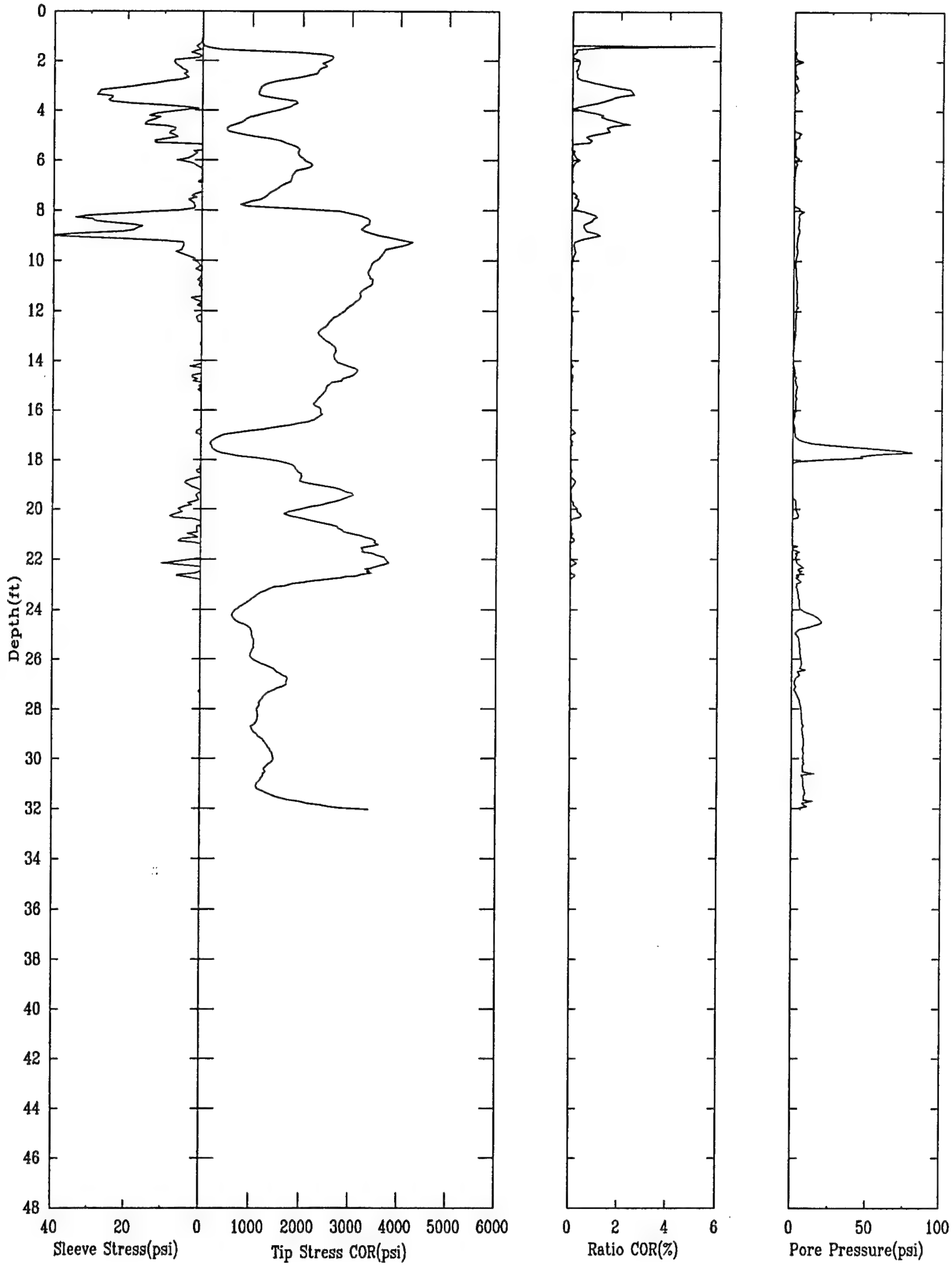


XYZ-CPT-02-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/11/94
Dover Air Force Base



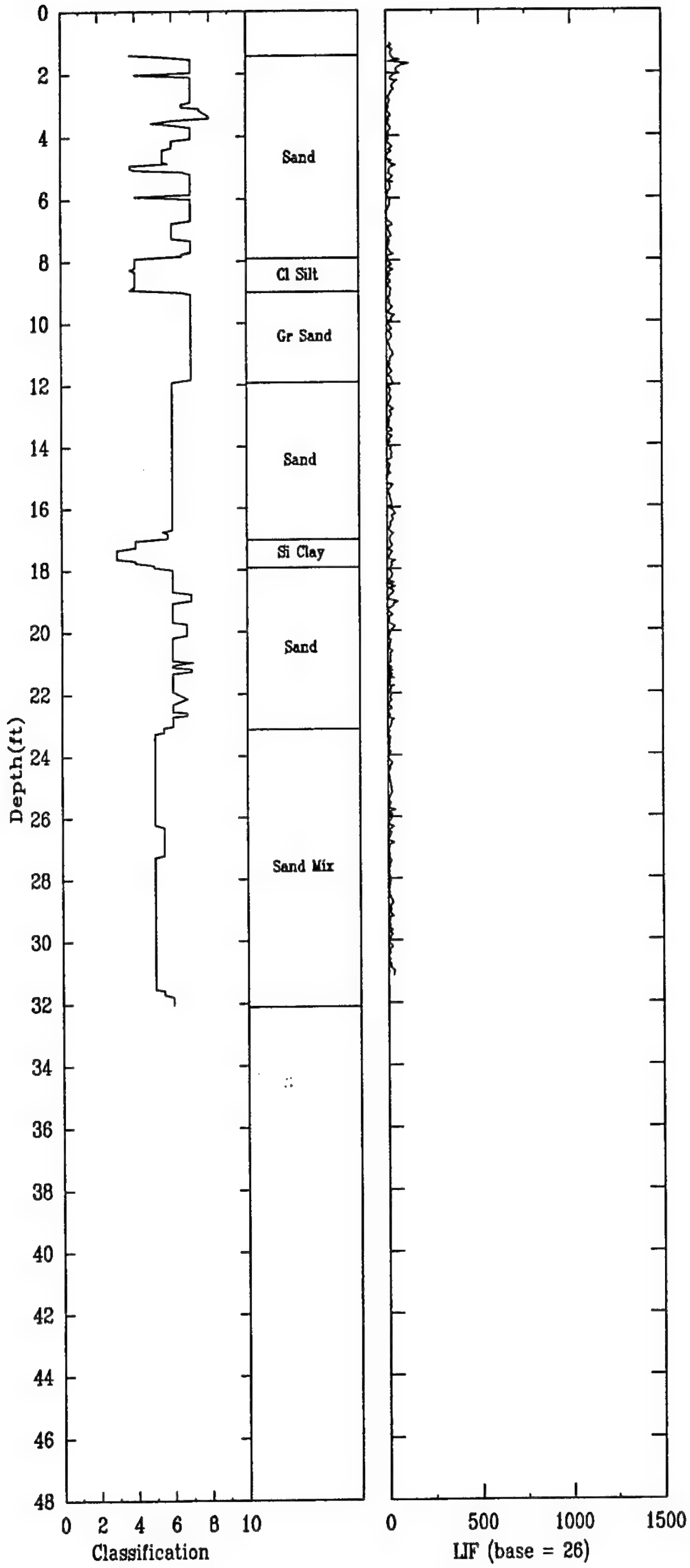
XYZ-CPT-03-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/12/94

Dover Air Force Base

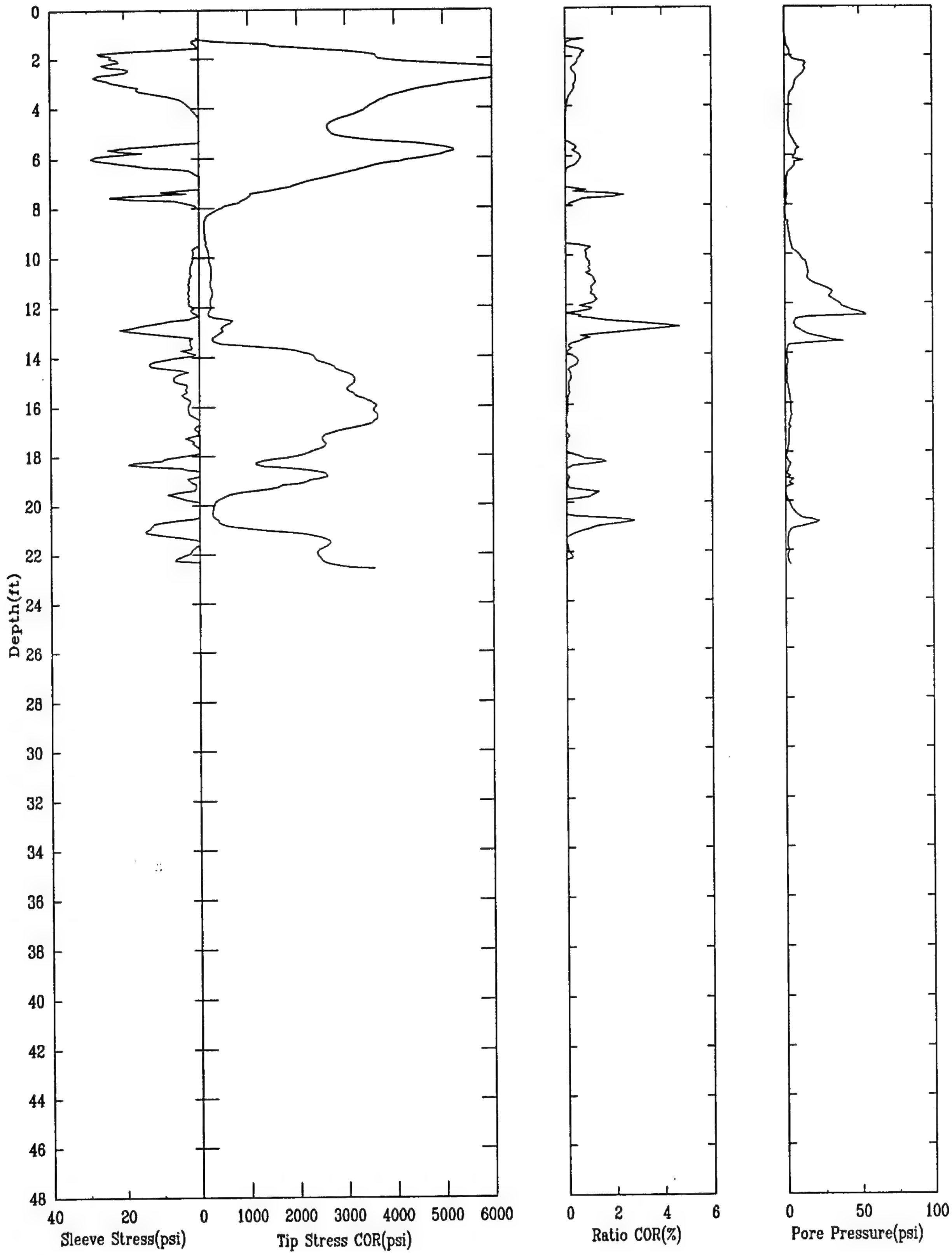


XYZ-CPT-03-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/12/94

Dover Air Force Base

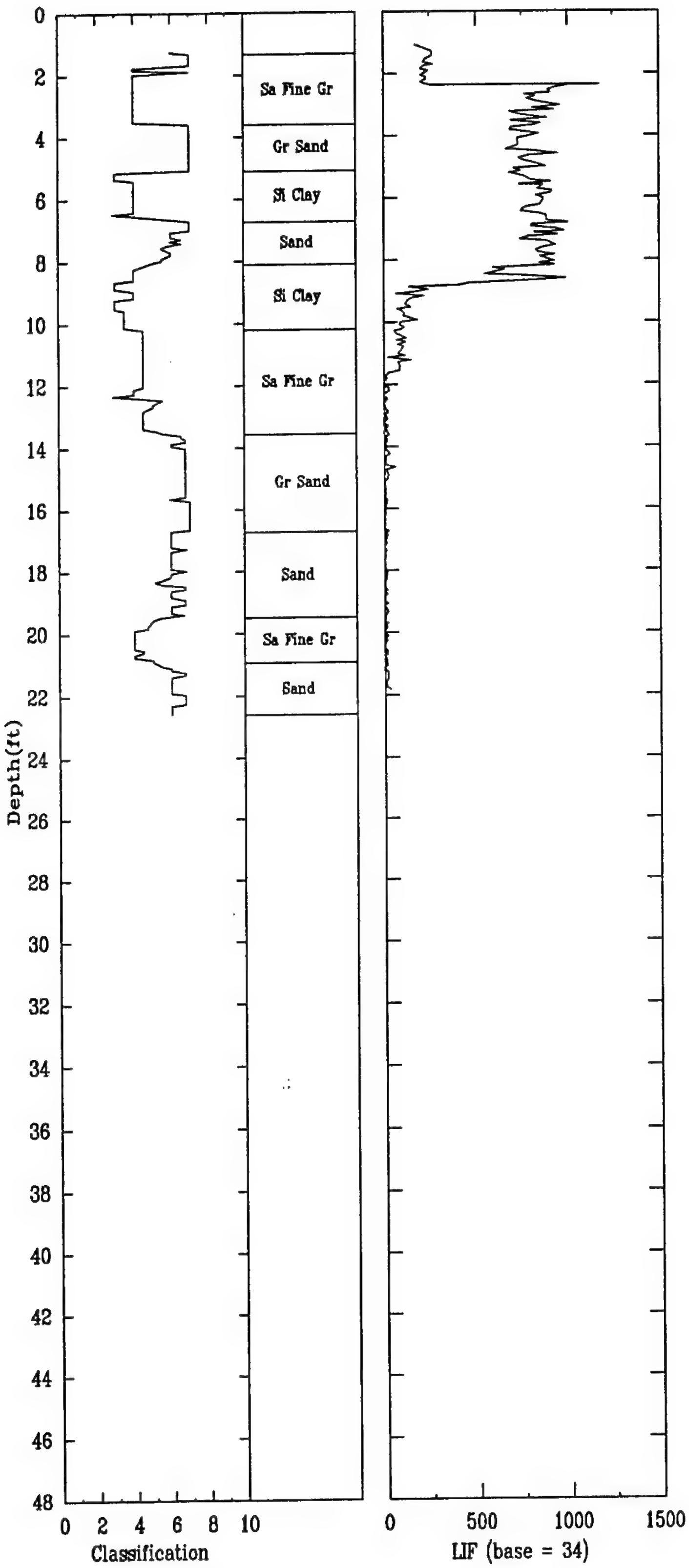


Dover Air Force Base



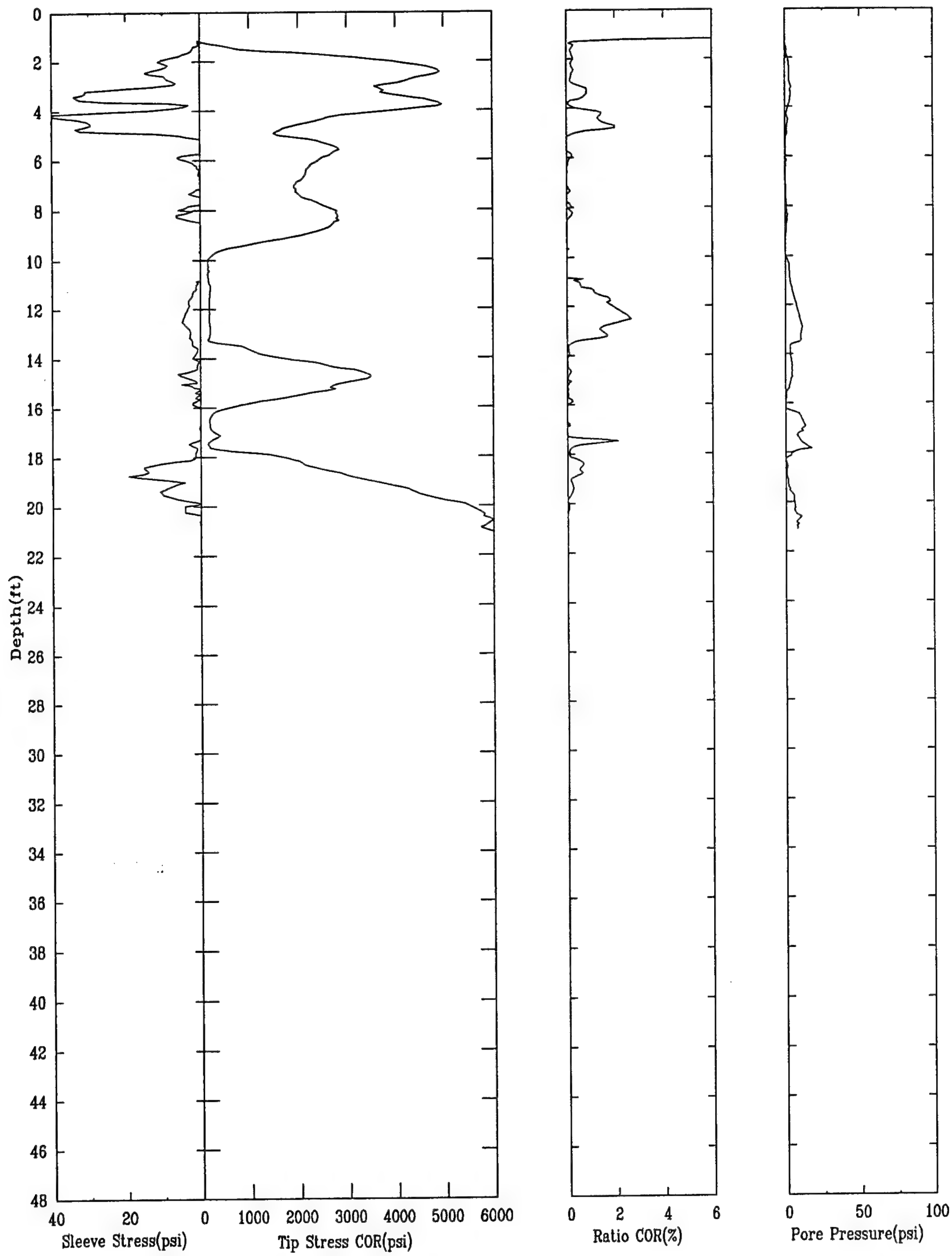
XYZ-CPT-04-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/12/94

Dover Air Force Base

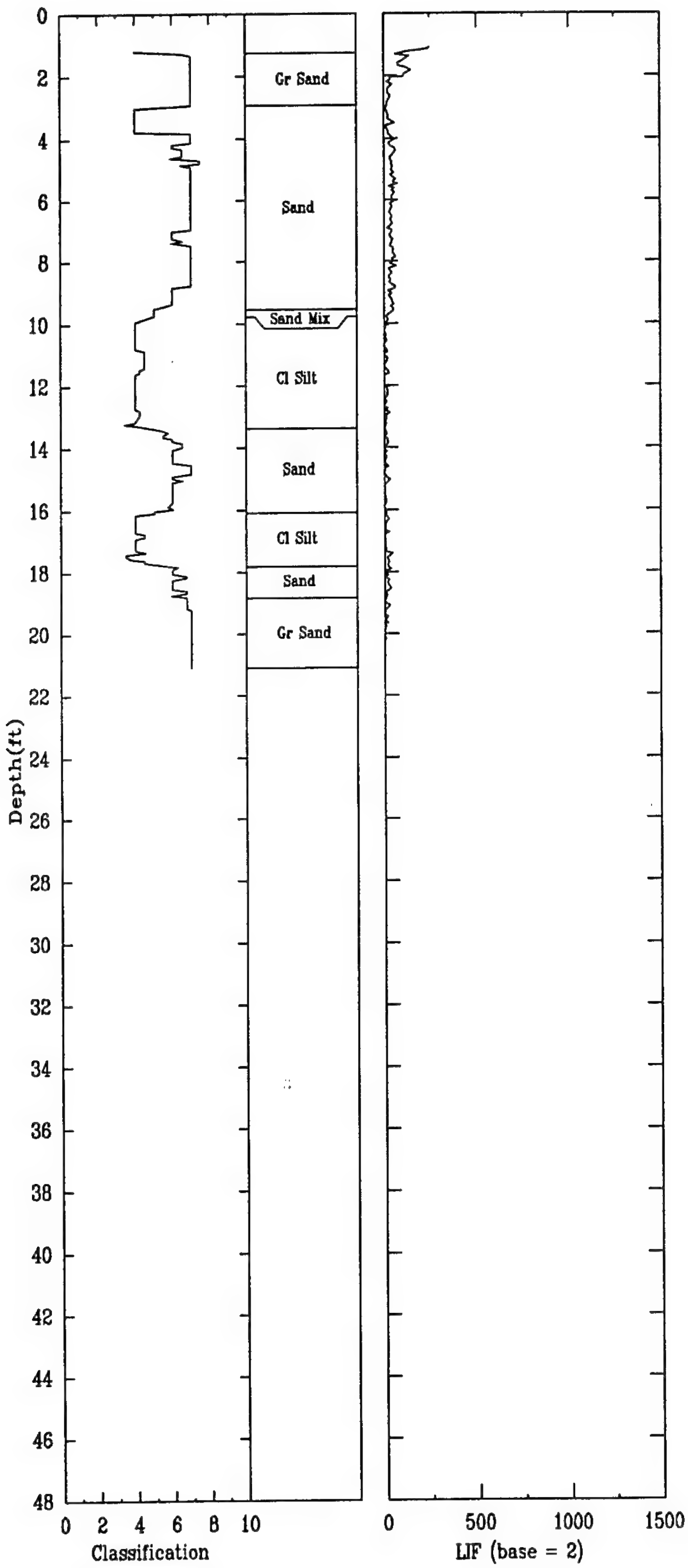


XYZ-CPT-05-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/12/94

Dover Air Force Base

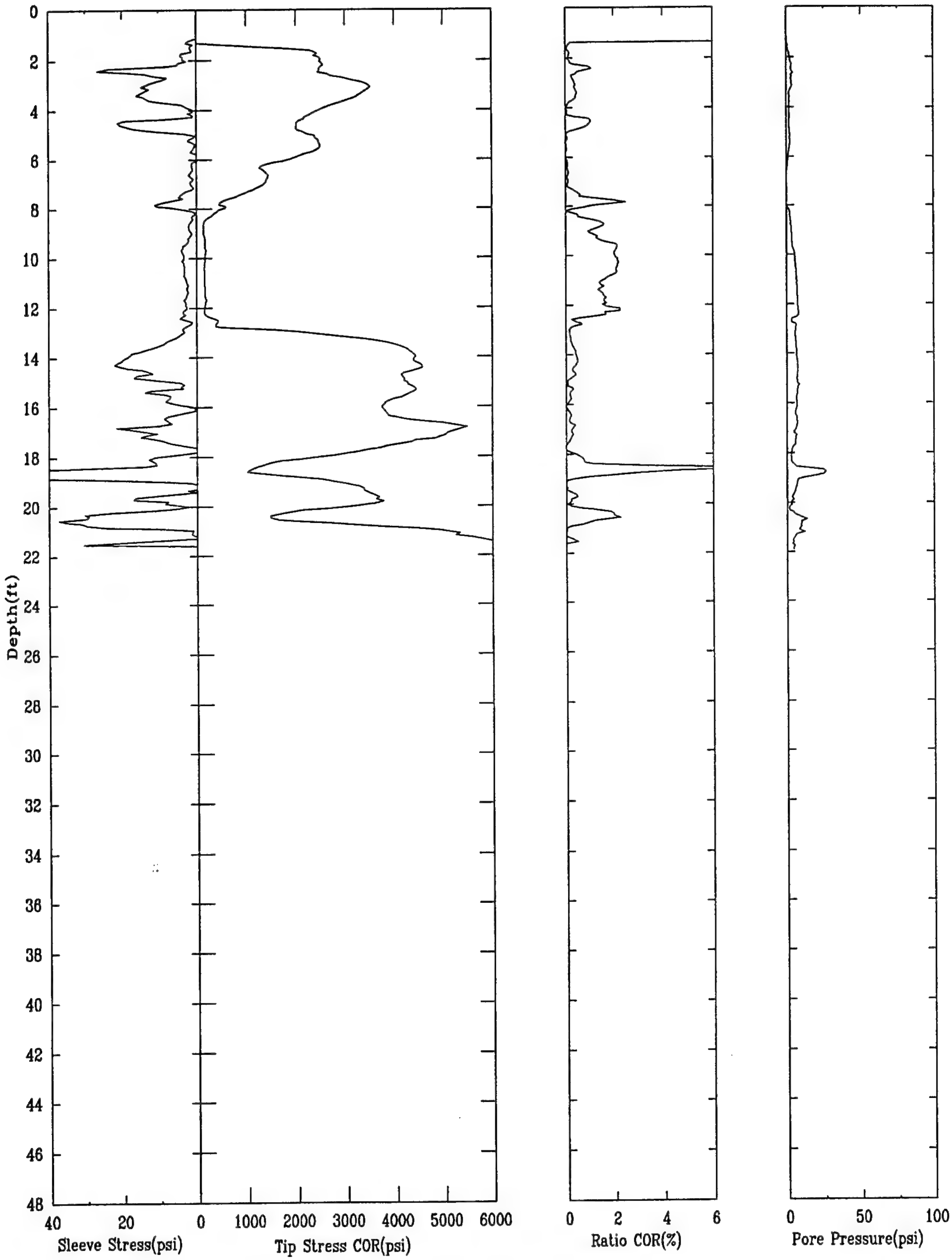


Dover Air Force Base

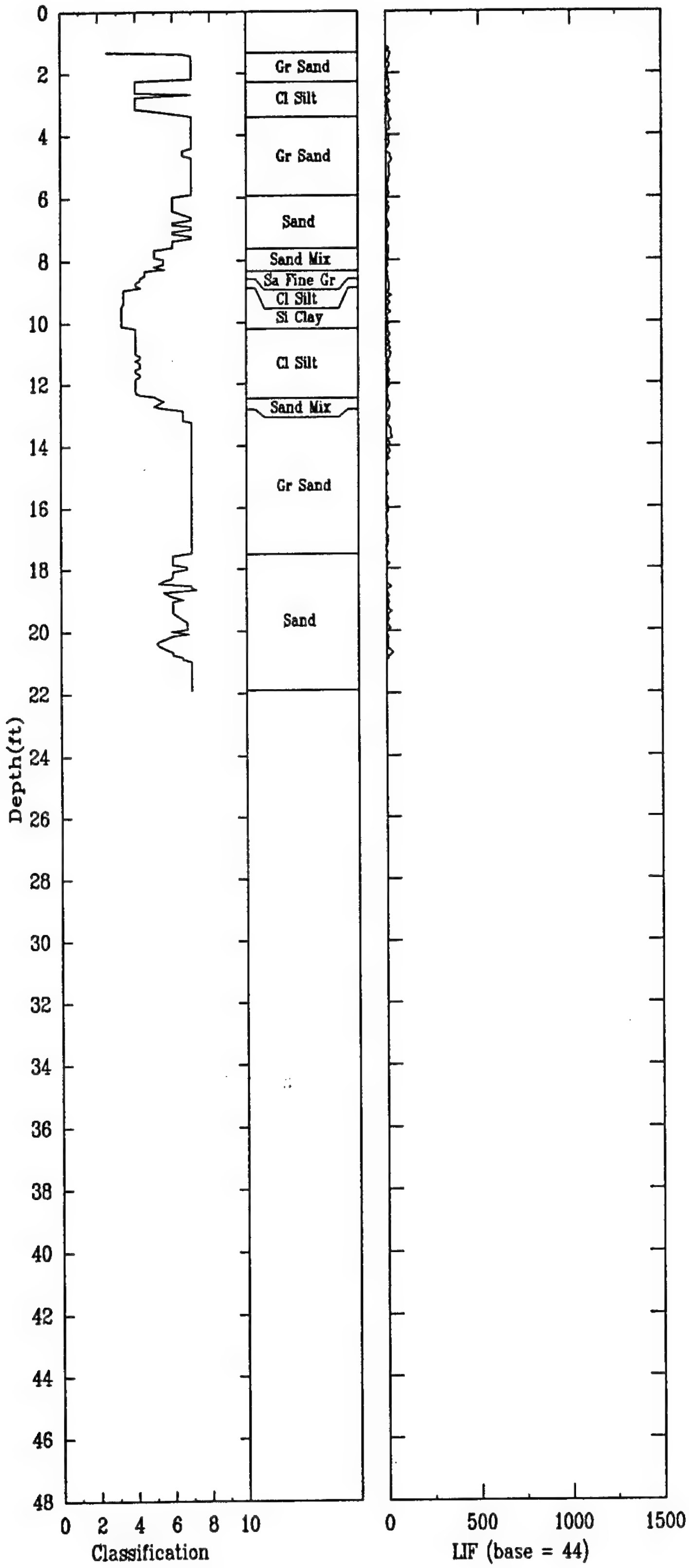


XYZ-CPT-06-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/12/94

Dover Air Force Base

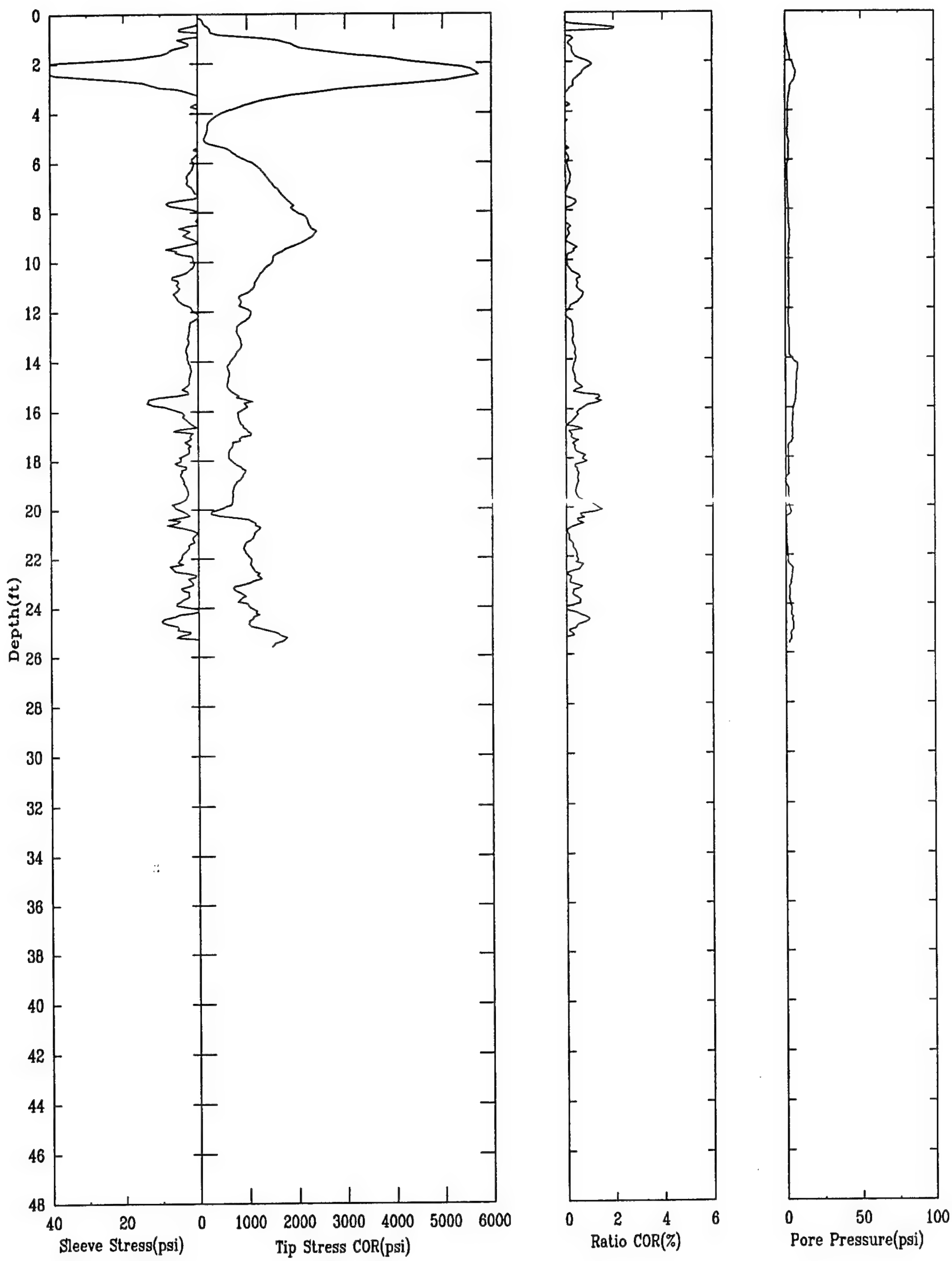


Dover Air Force Base

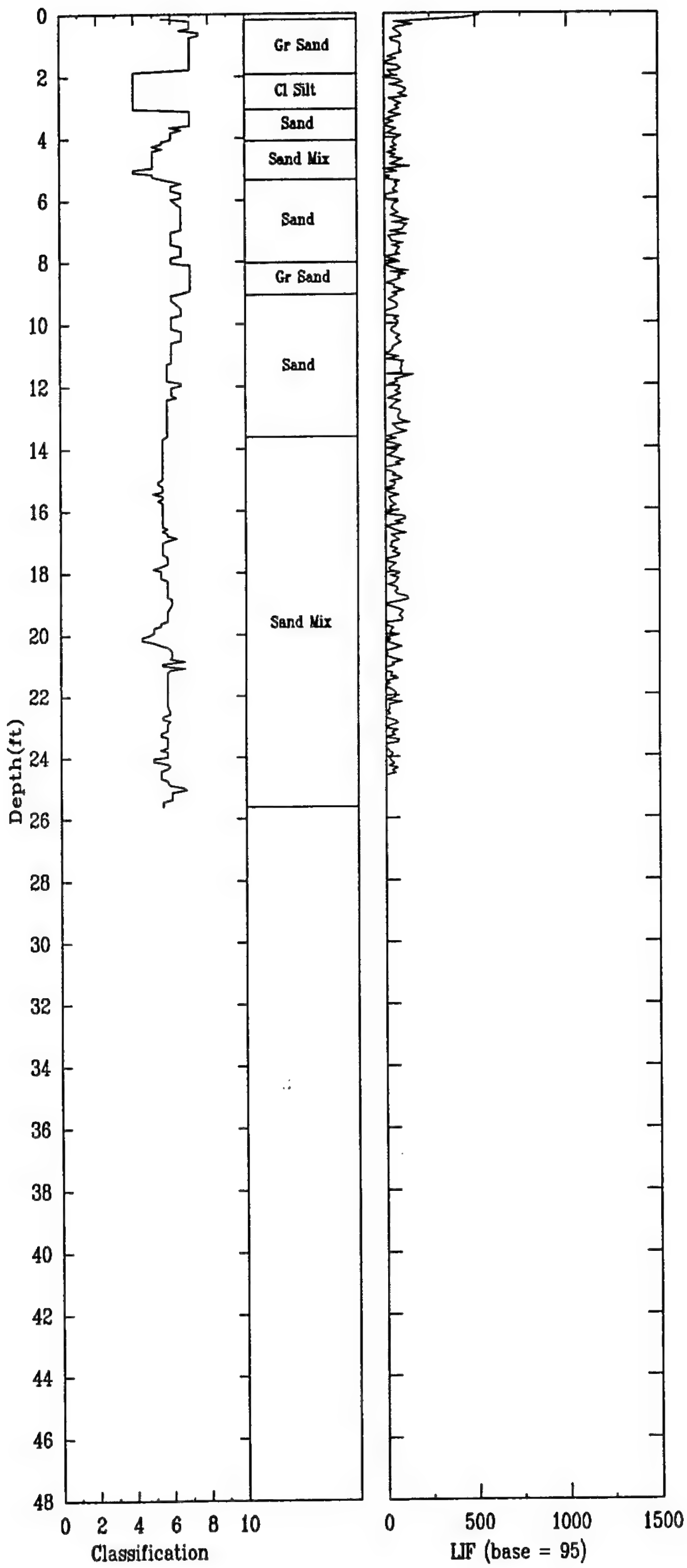


XYZ-CPT-07-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base

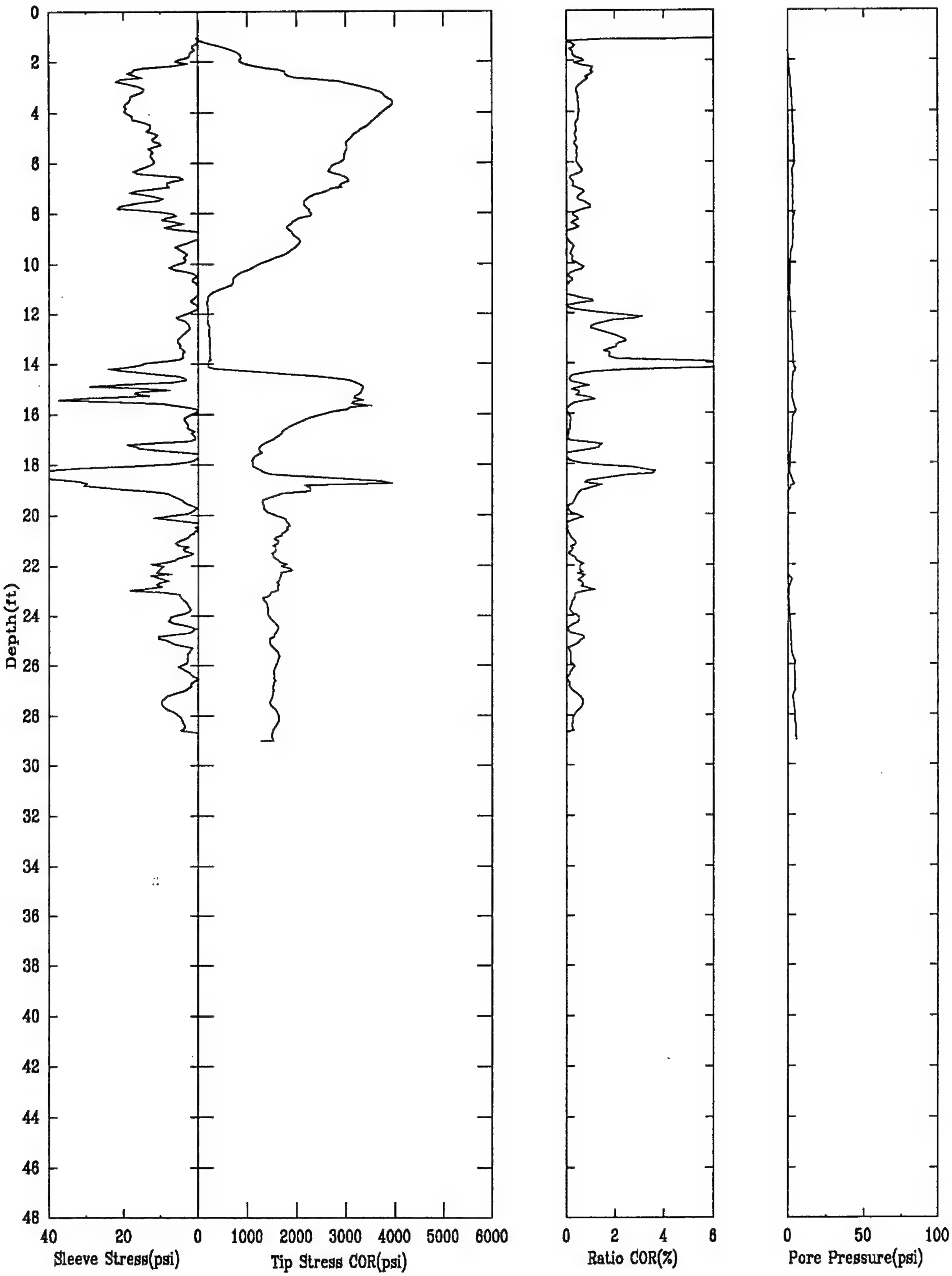


Dover Air Force Base



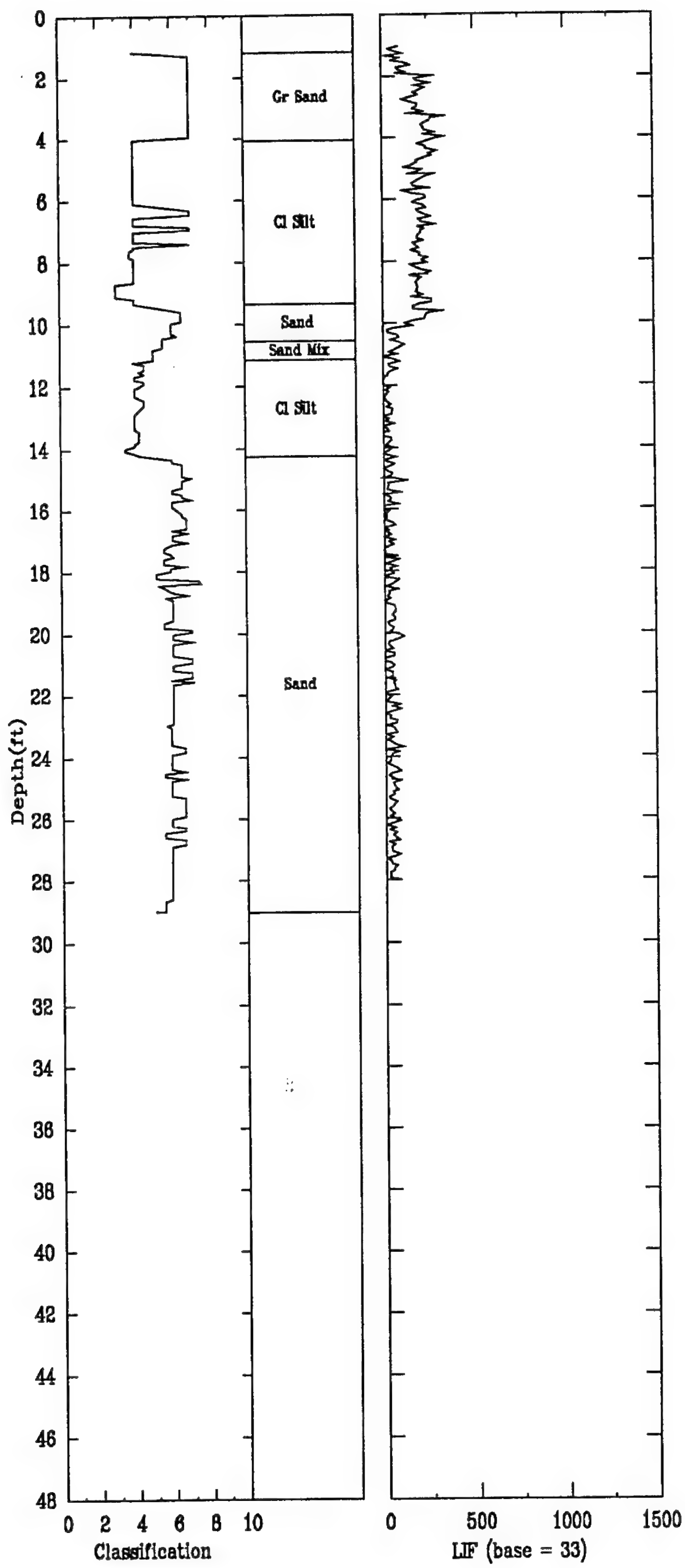
XYZ-CPT-08-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base



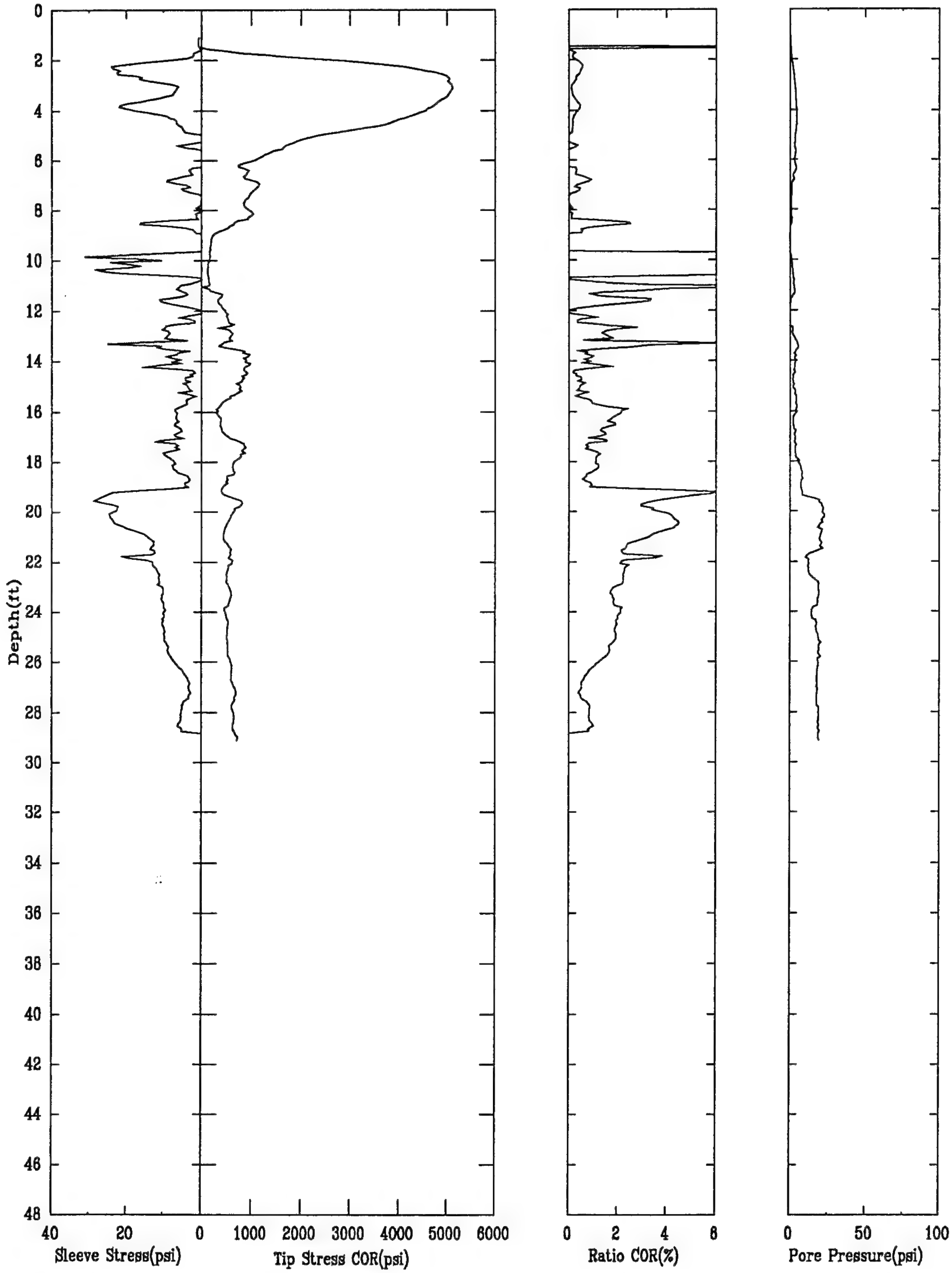
XYZ-CPT-08-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base



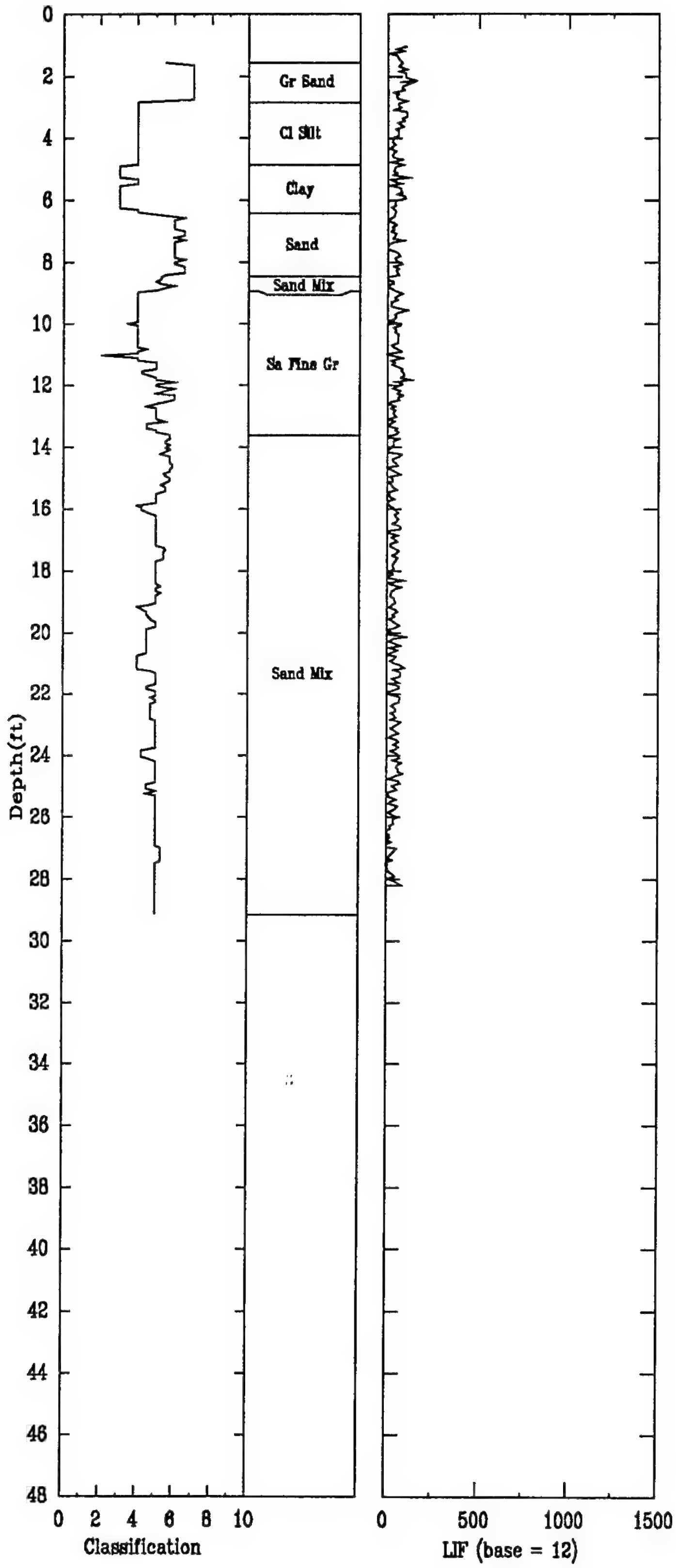
XYZ-CPT-09-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base



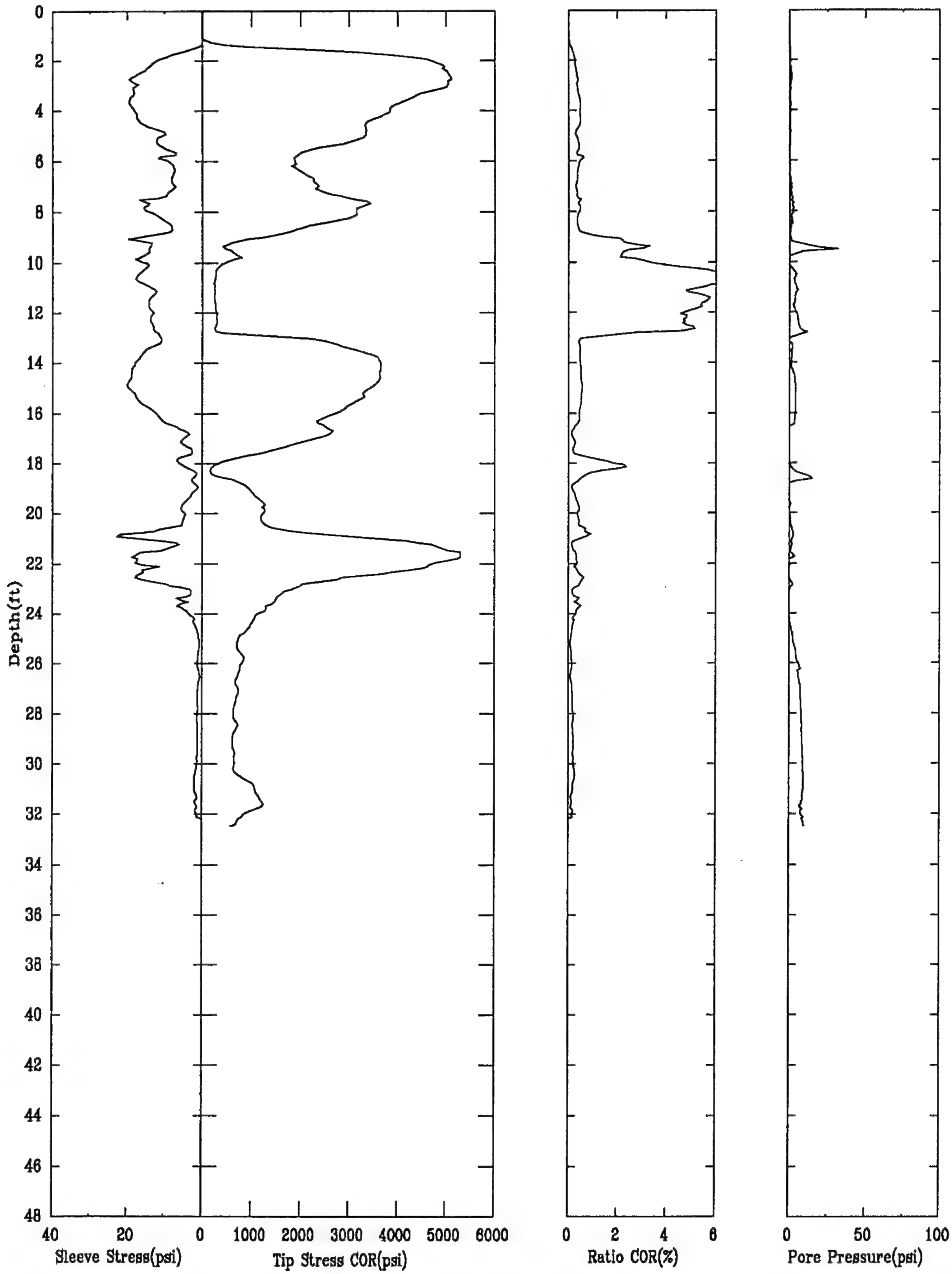
XYZ-CPT-09-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base



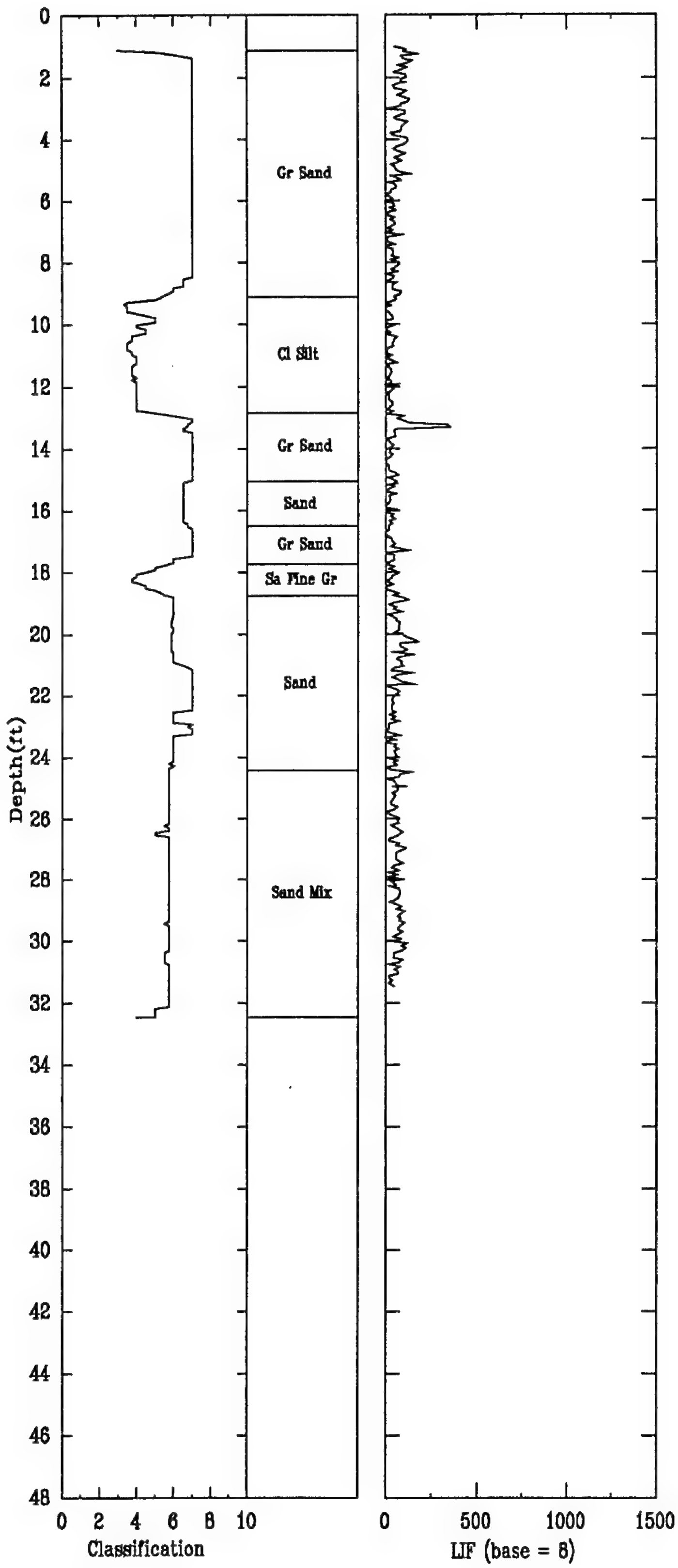
XYZ-CPT-10-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base



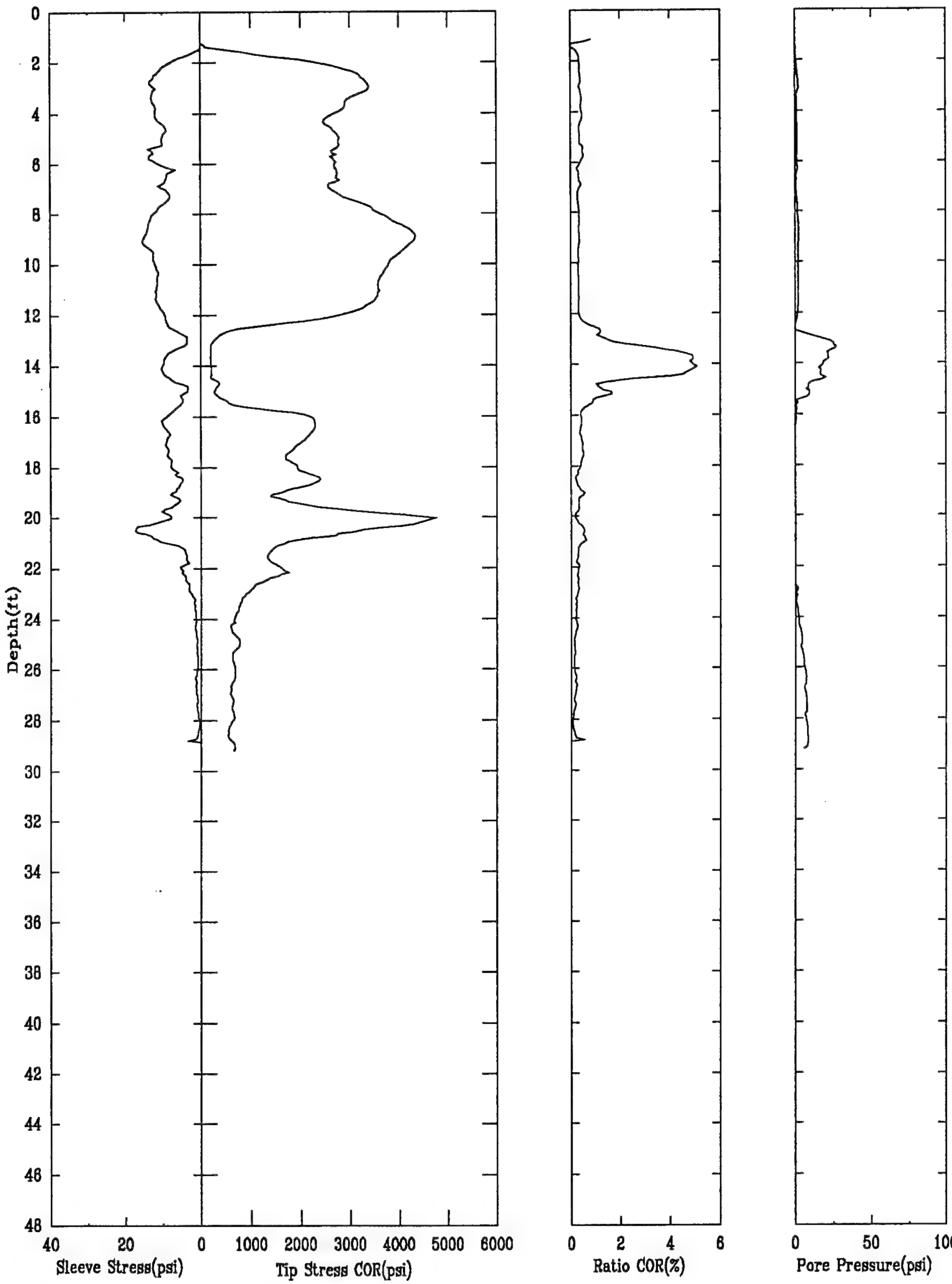
XYZ-CPT-10-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base

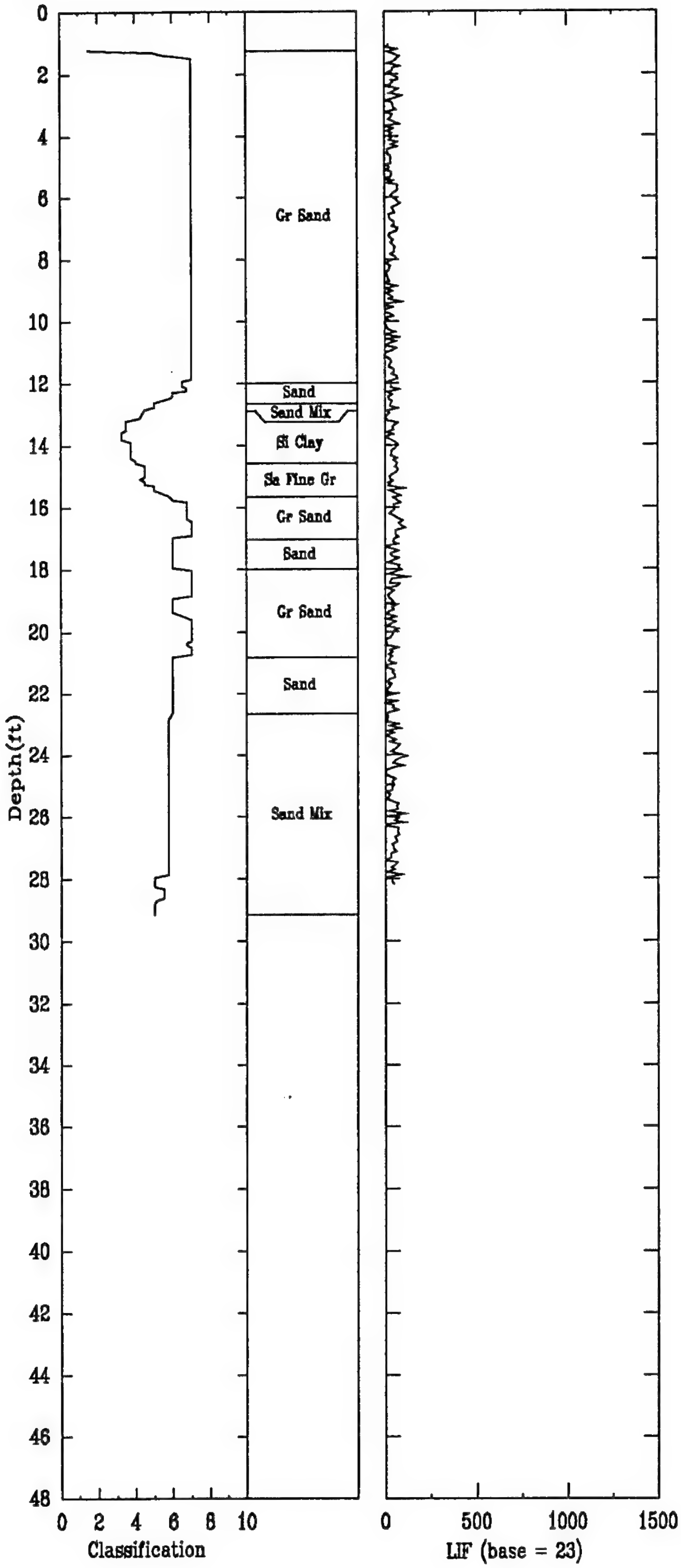


XYZ-CPT-11-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/13/94

Dover Air Force Base

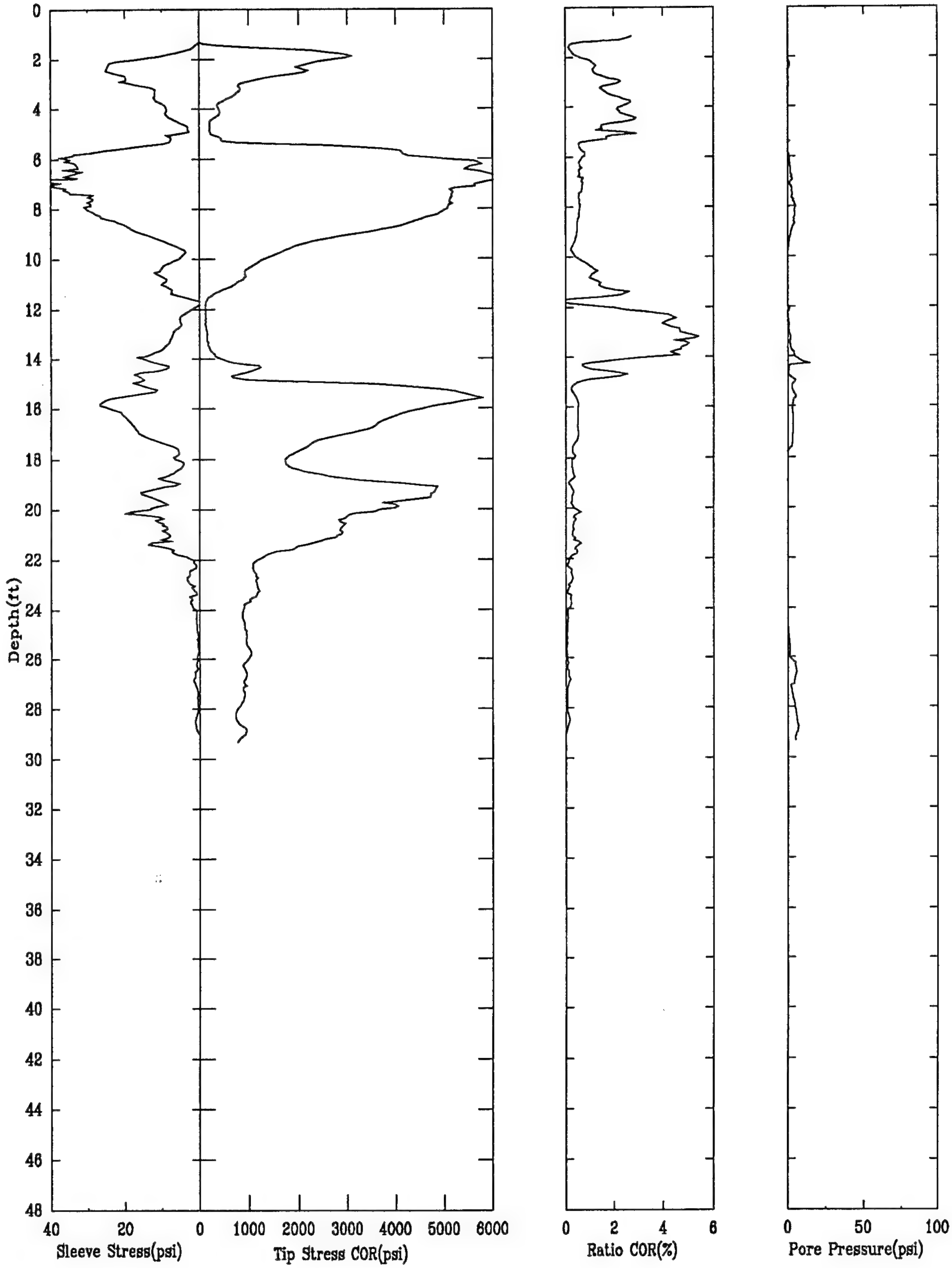


Dover Air Force Base

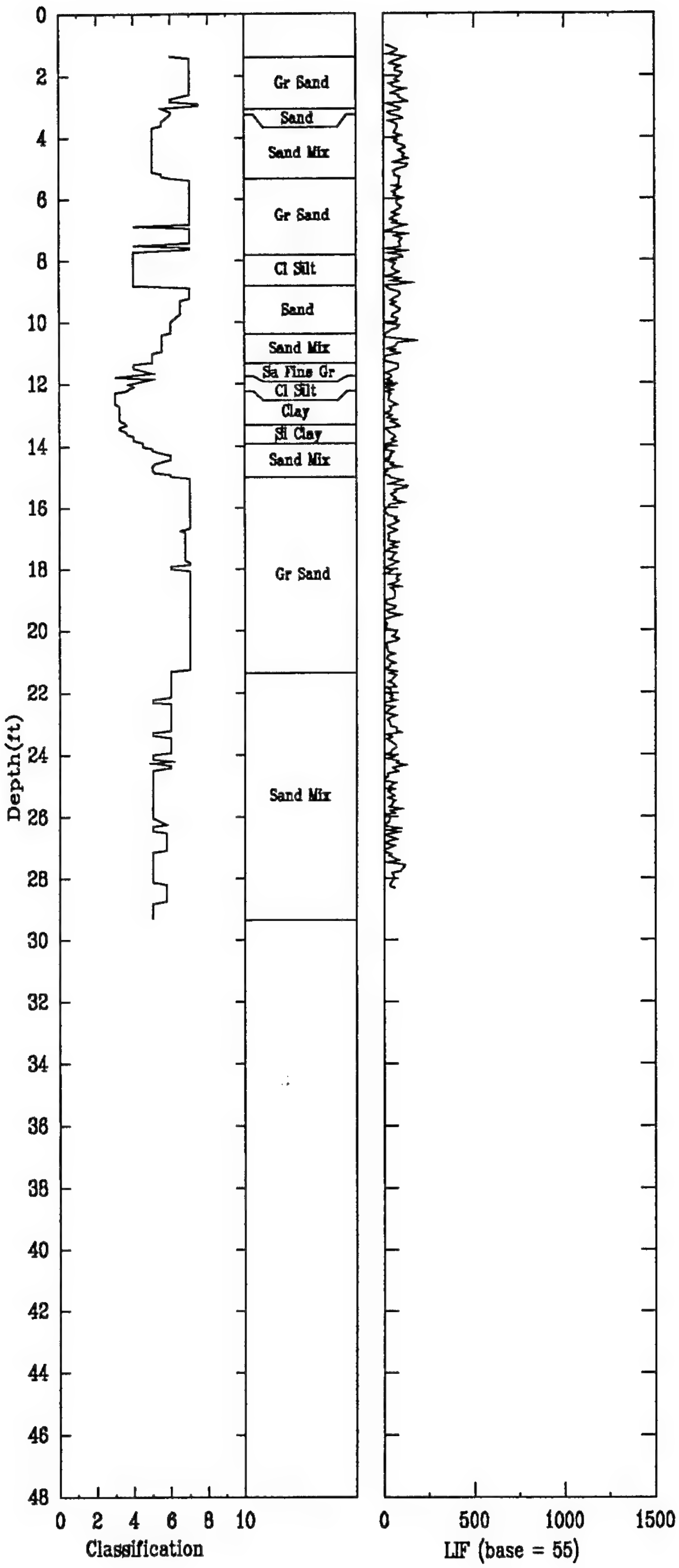


XYZ-CPT-12-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base

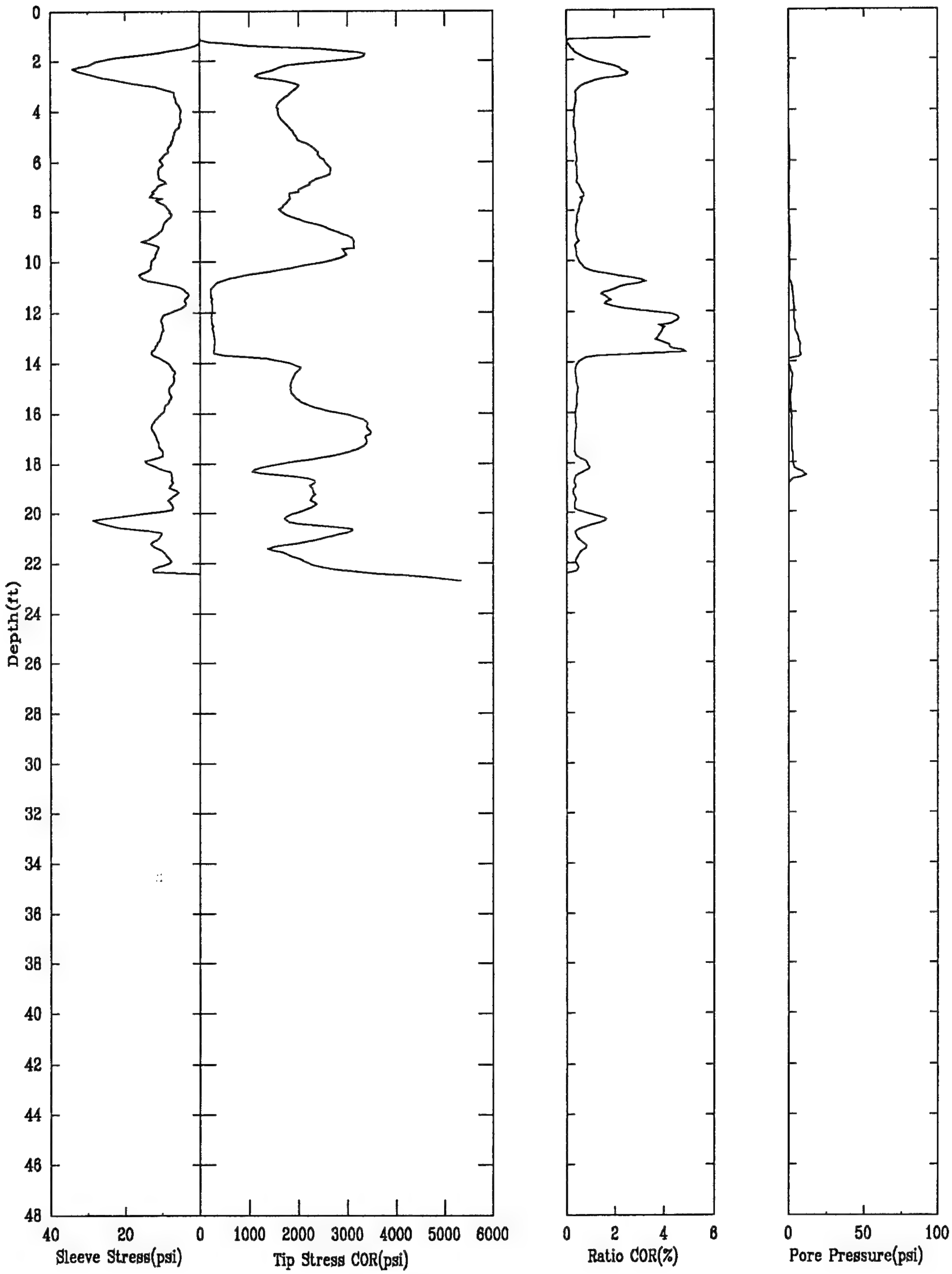


Dover Air Force Base

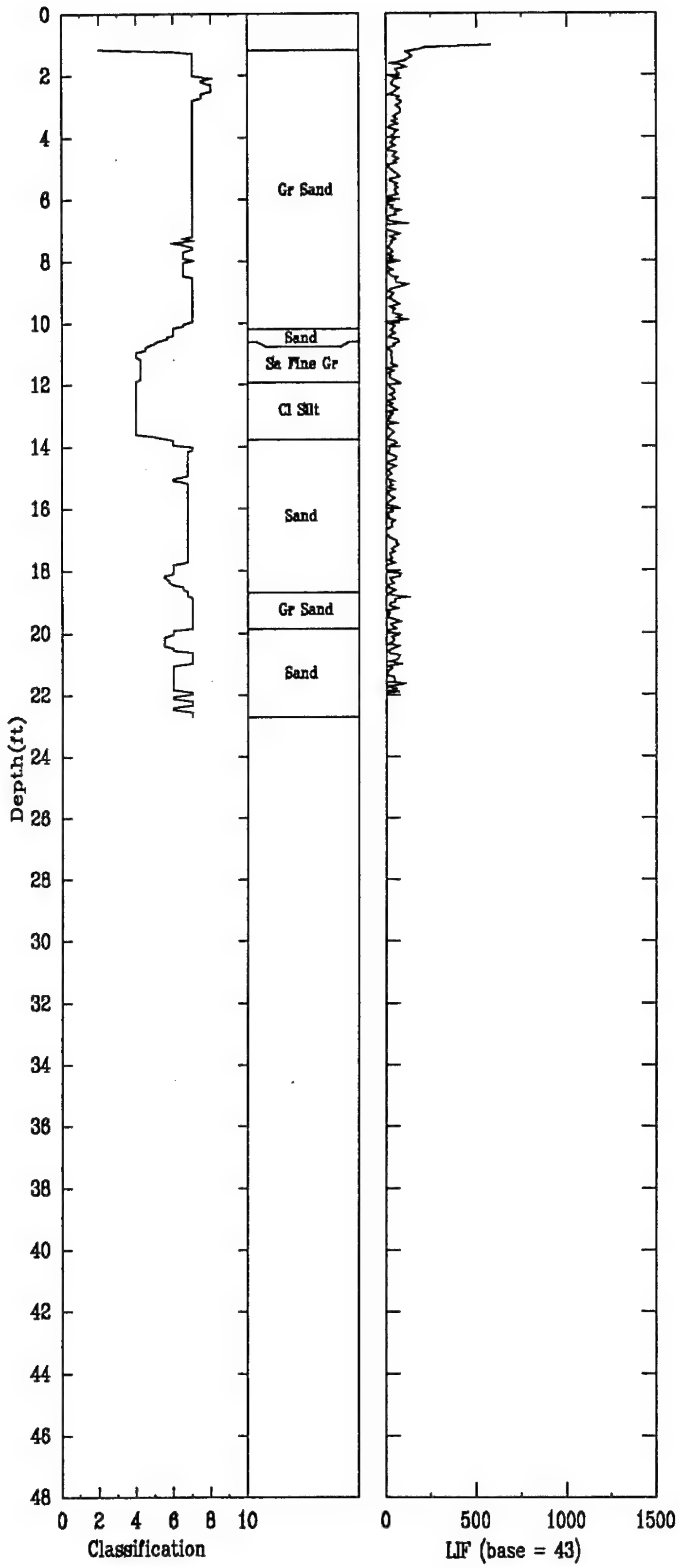


XYZ-CPT-13-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



Dover Air Force Base



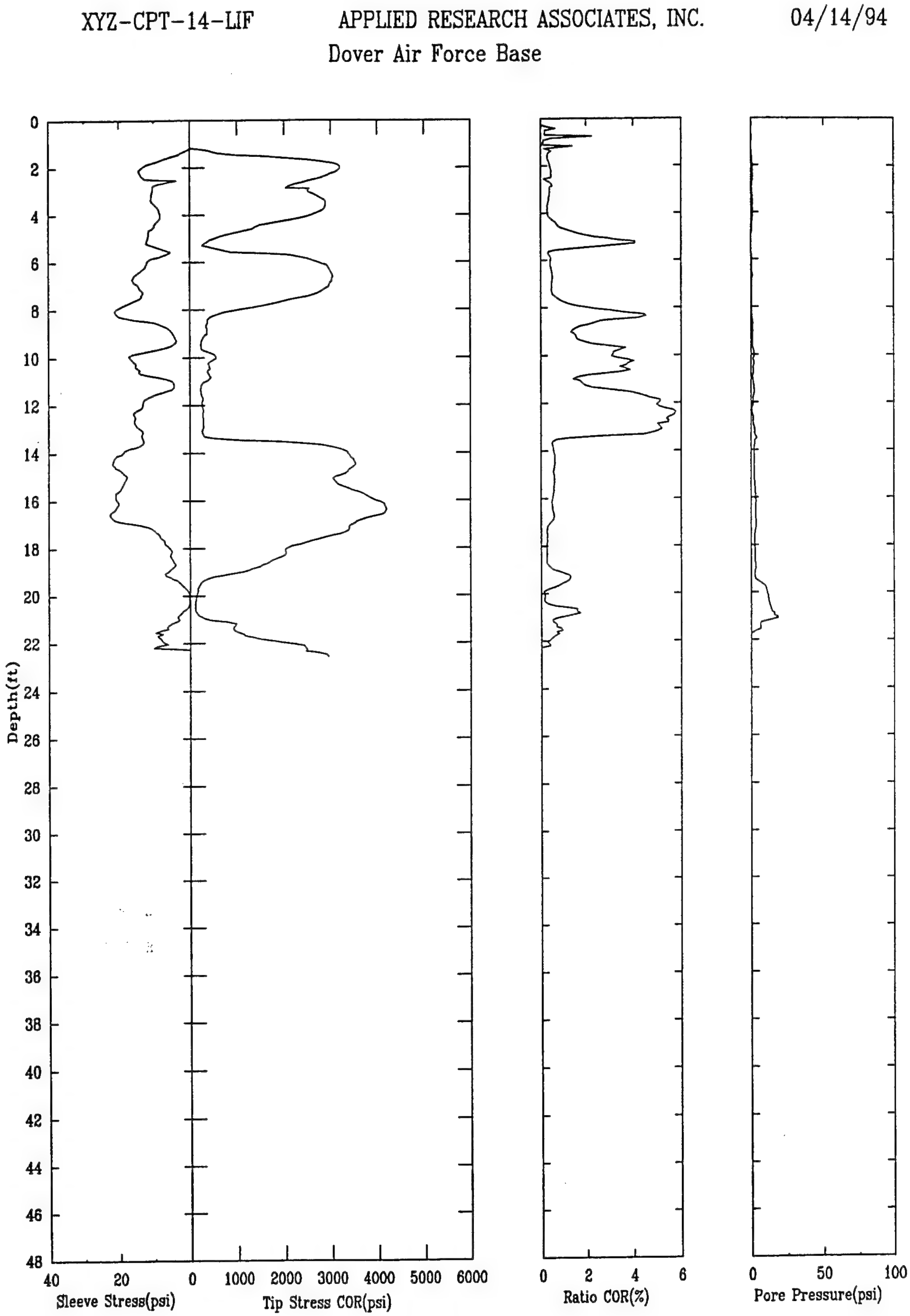


Figure 4. LIF-CPT profiles for XYZCPT-14-LIF.

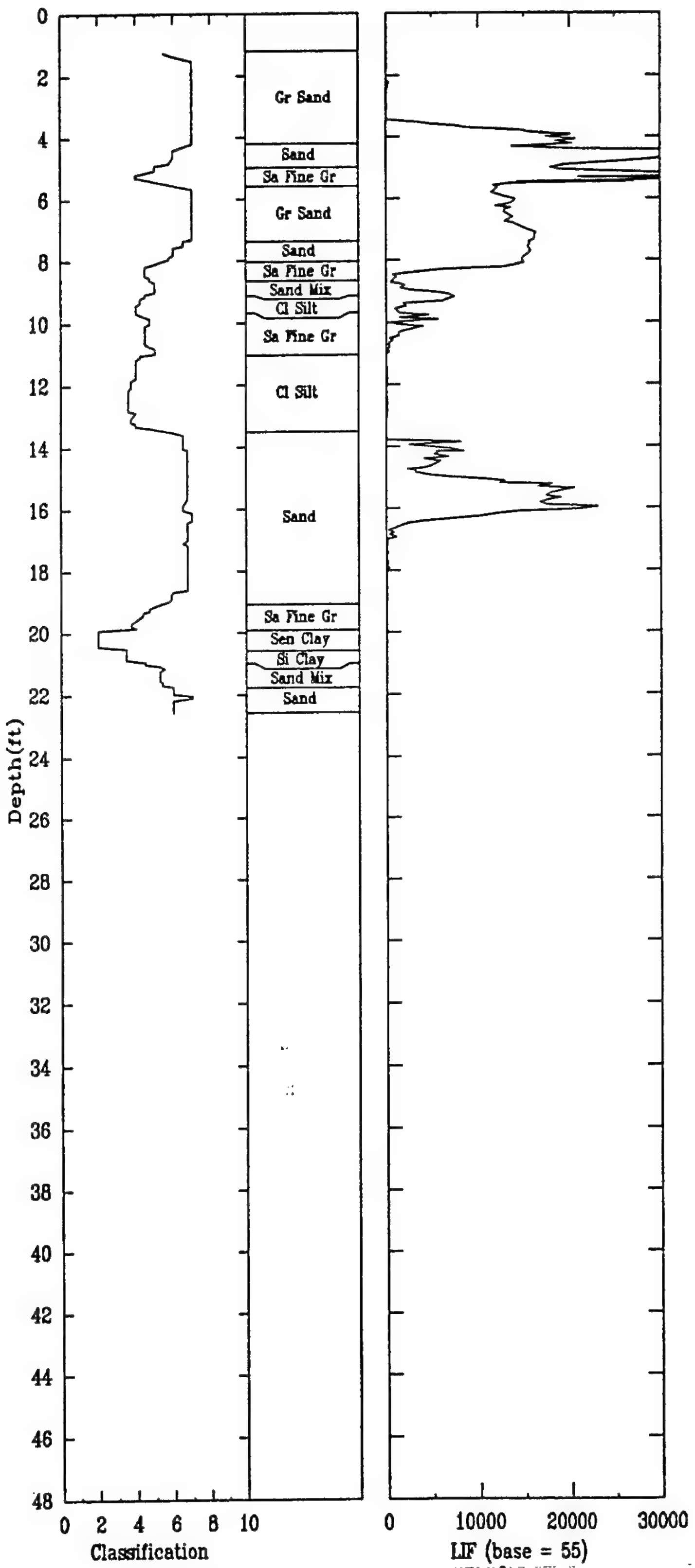
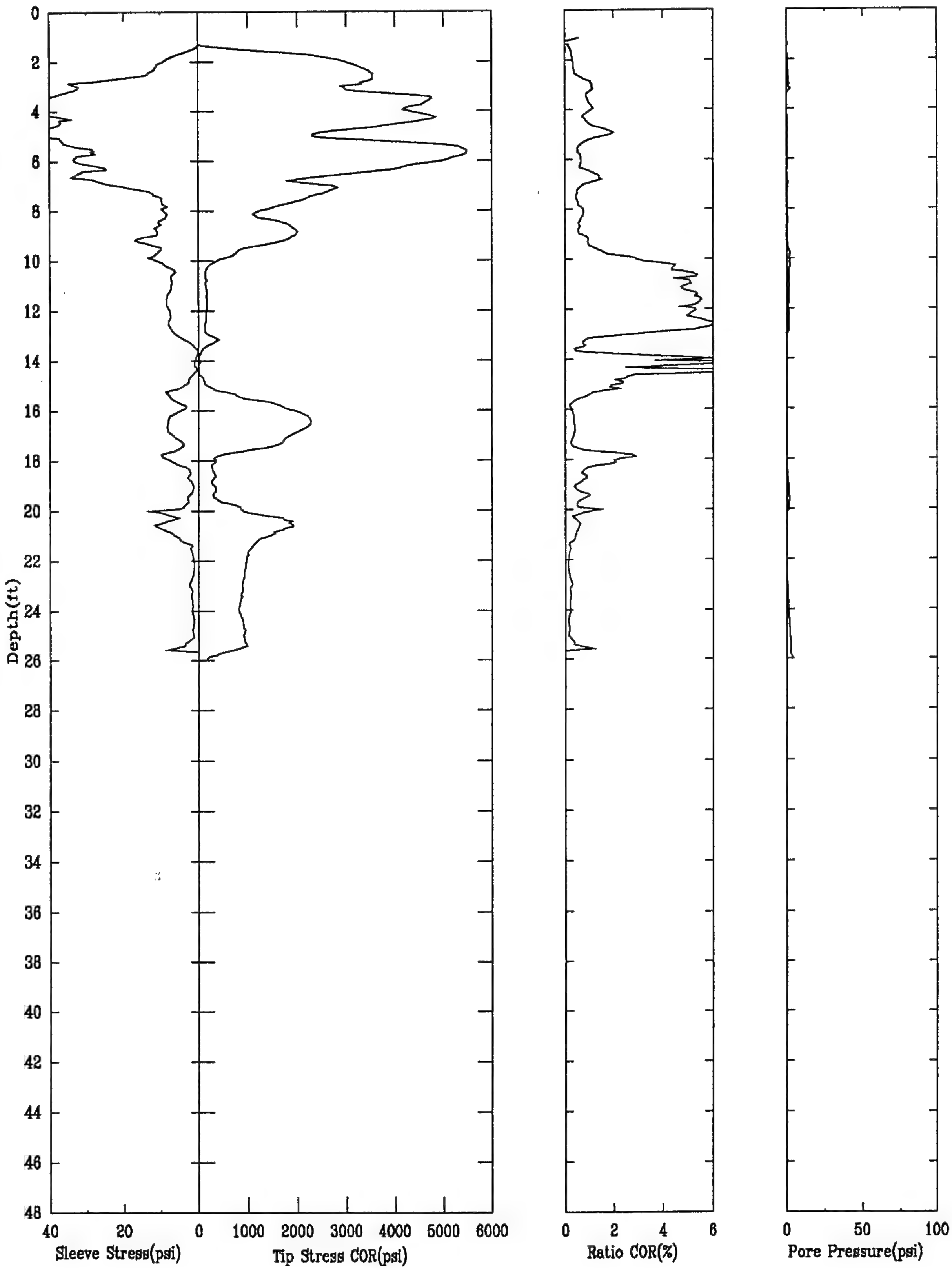


Figure 4. LIF-CPT profiles for XYZCPT-14-LIF (continued).

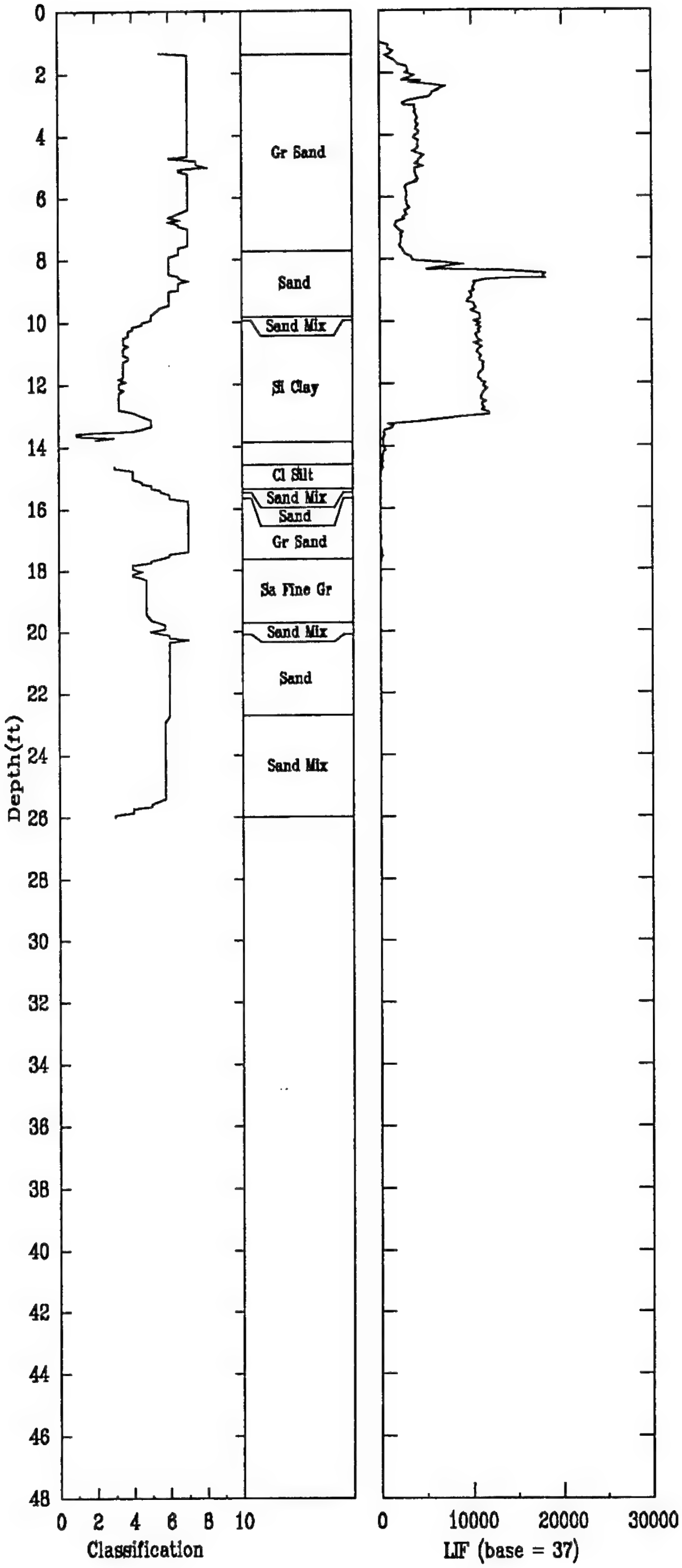
XYZ-CPT-15-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



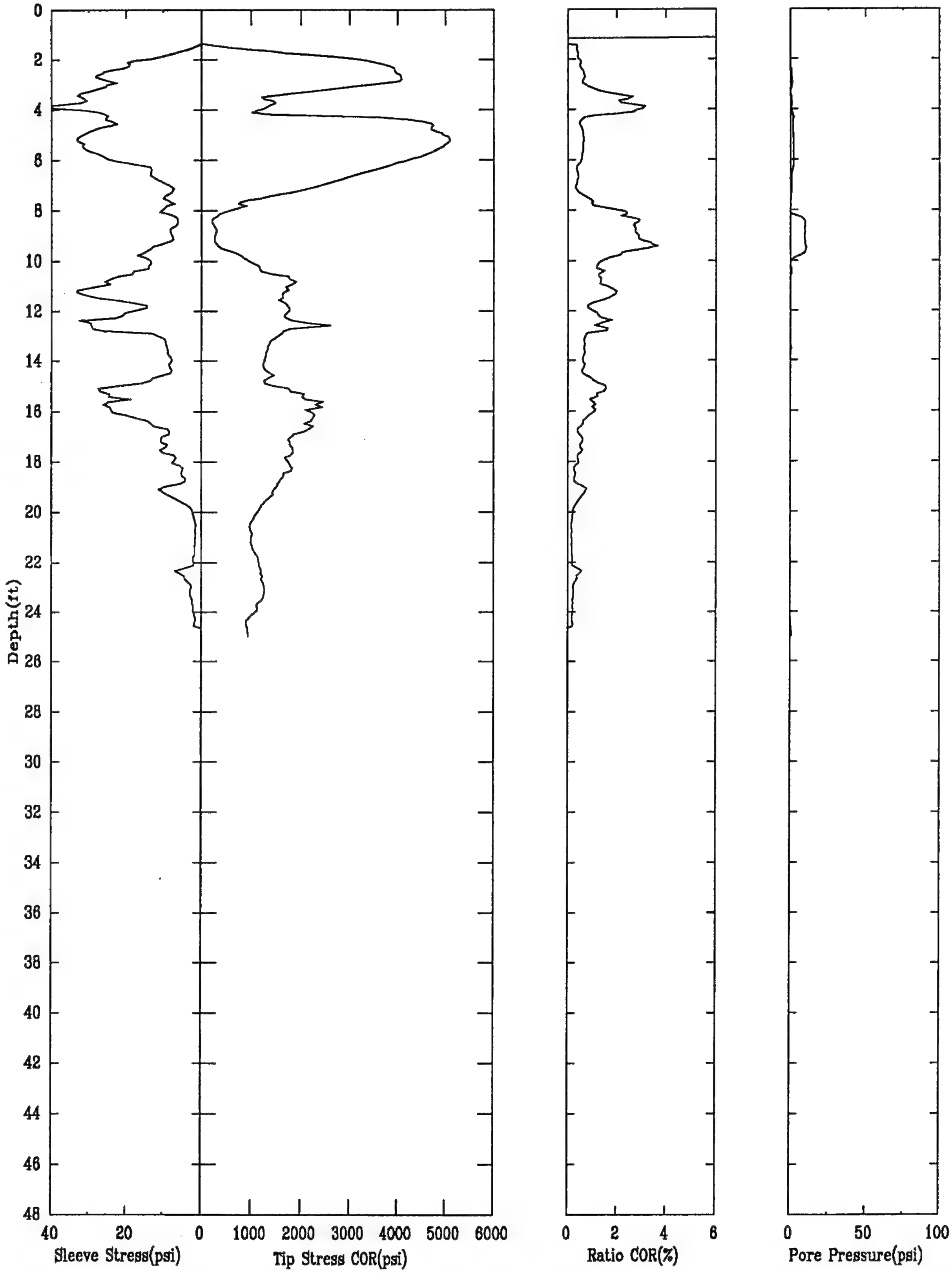
XYZ-CPT-15-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



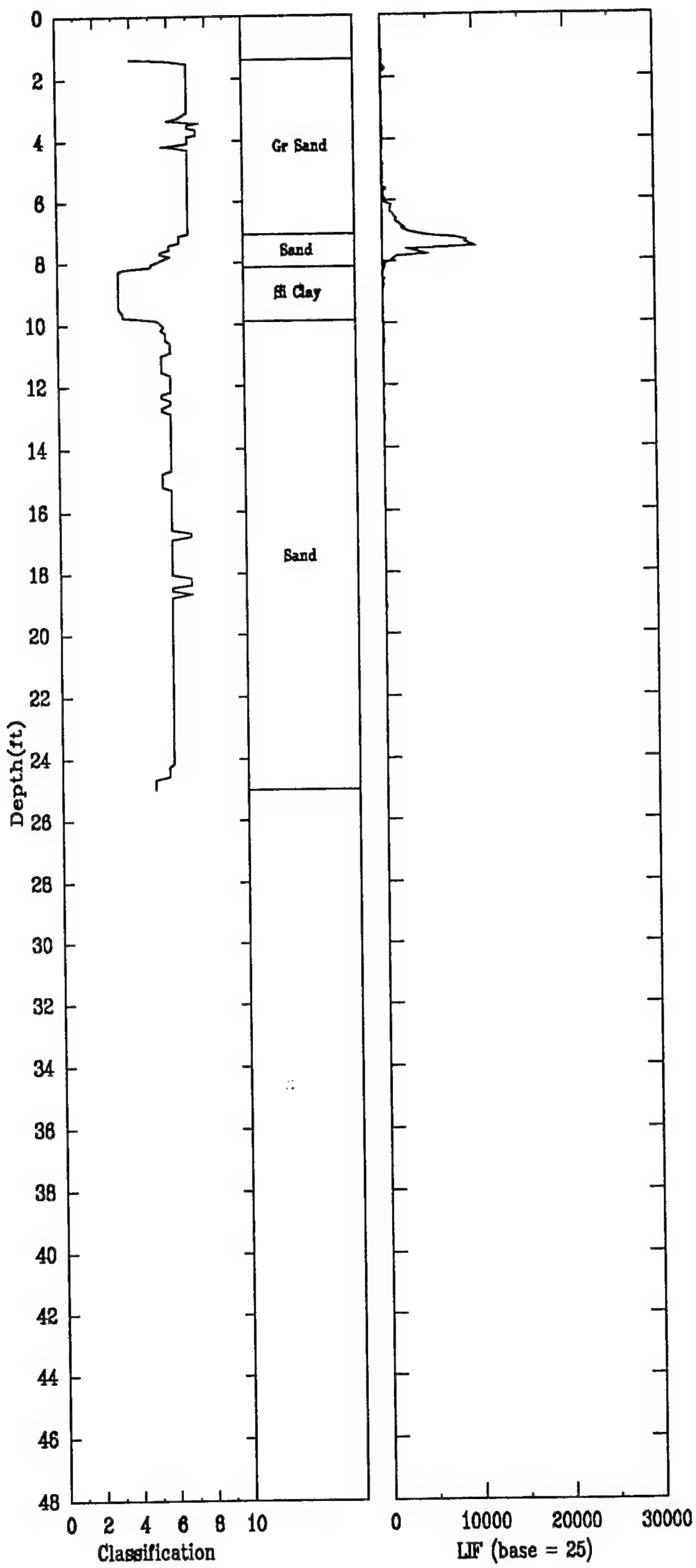
XYZ-CPT-16-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



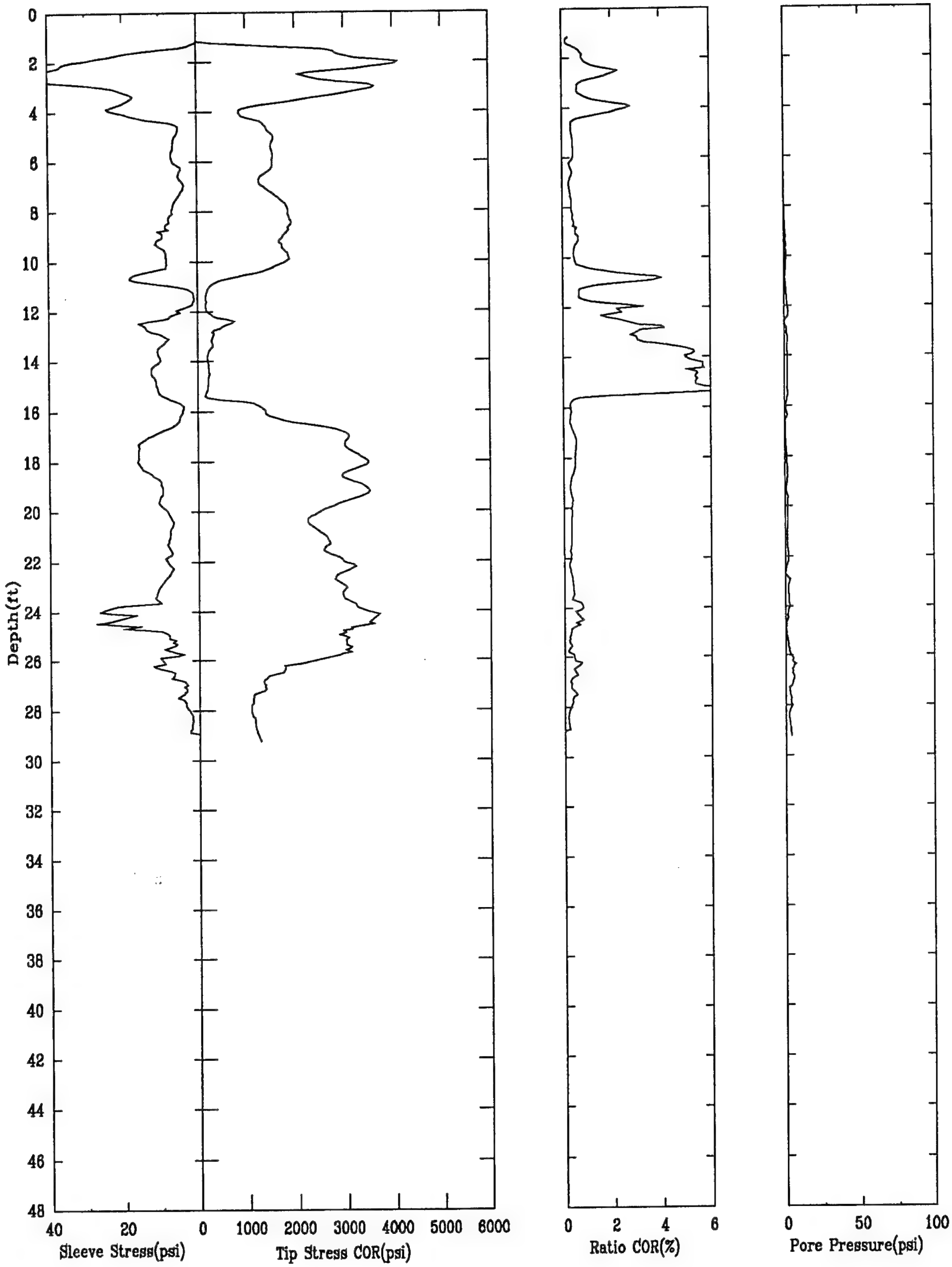
XYZ-CPT-16-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



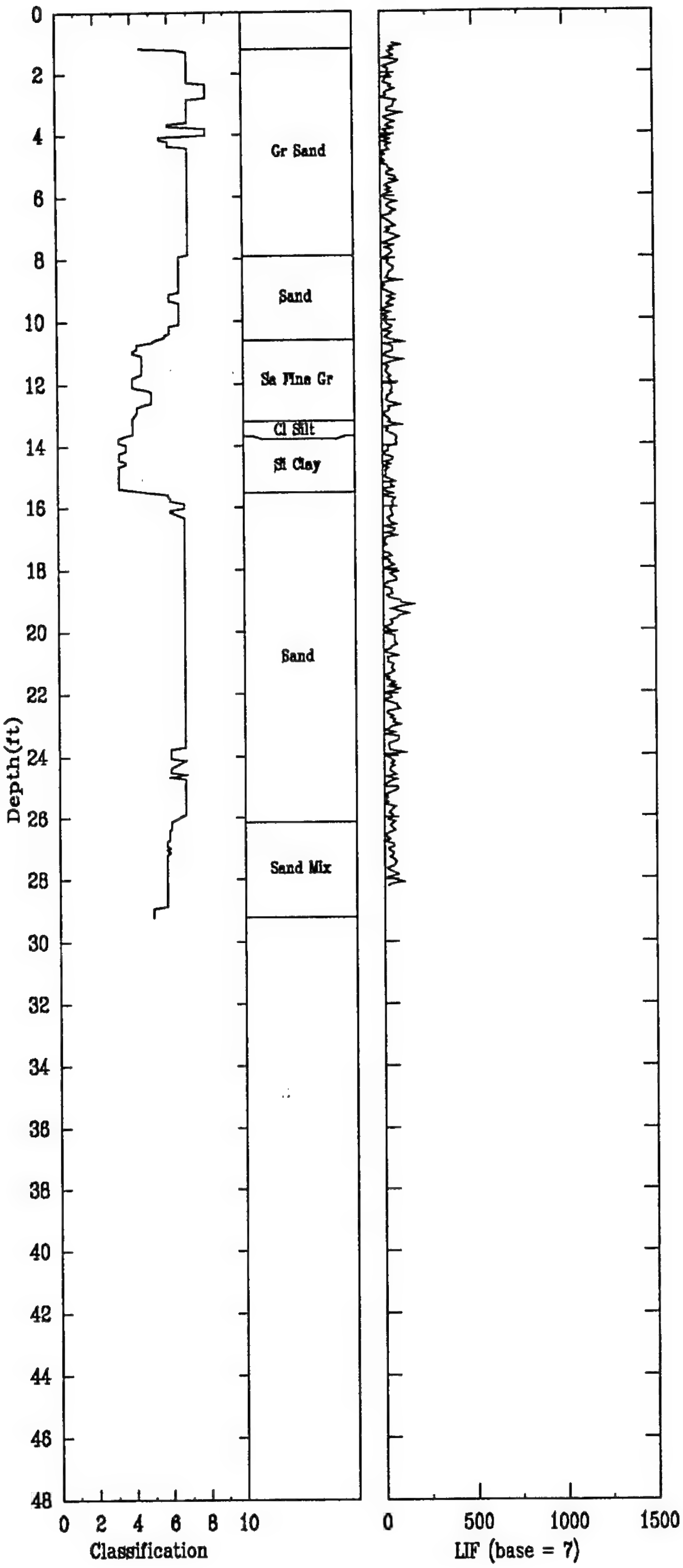
XYZ-CPT-17-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



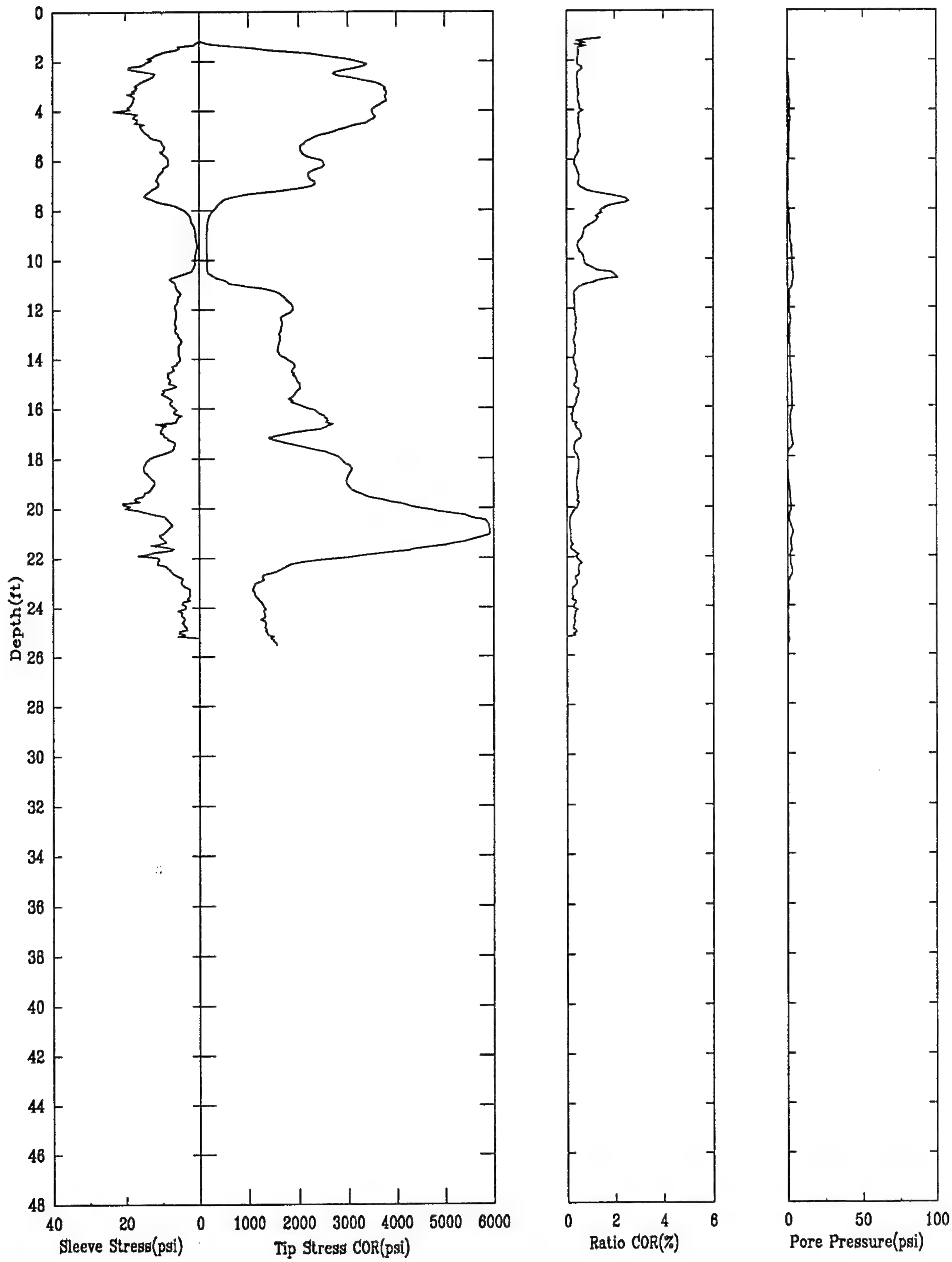
XYZ-CPT-17-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



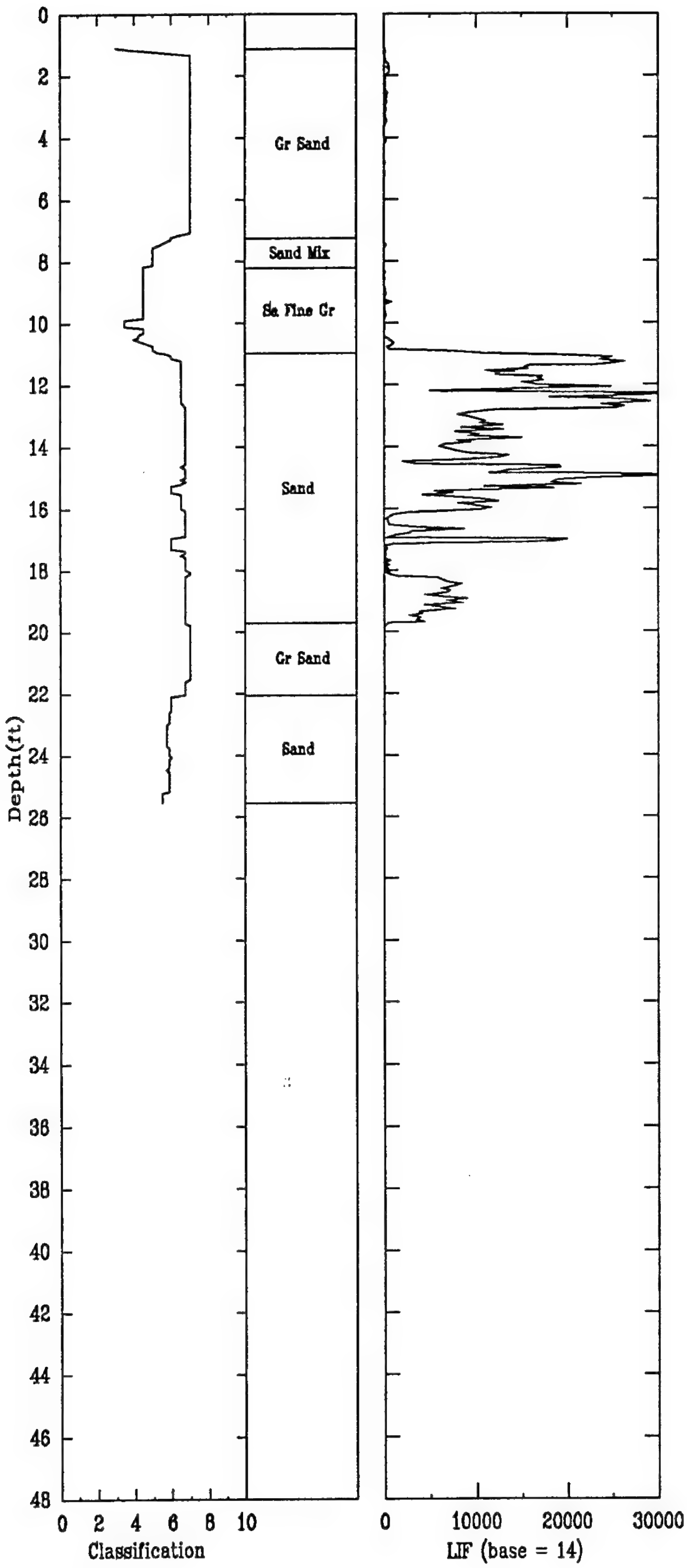
XYZ-CPT-18-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base

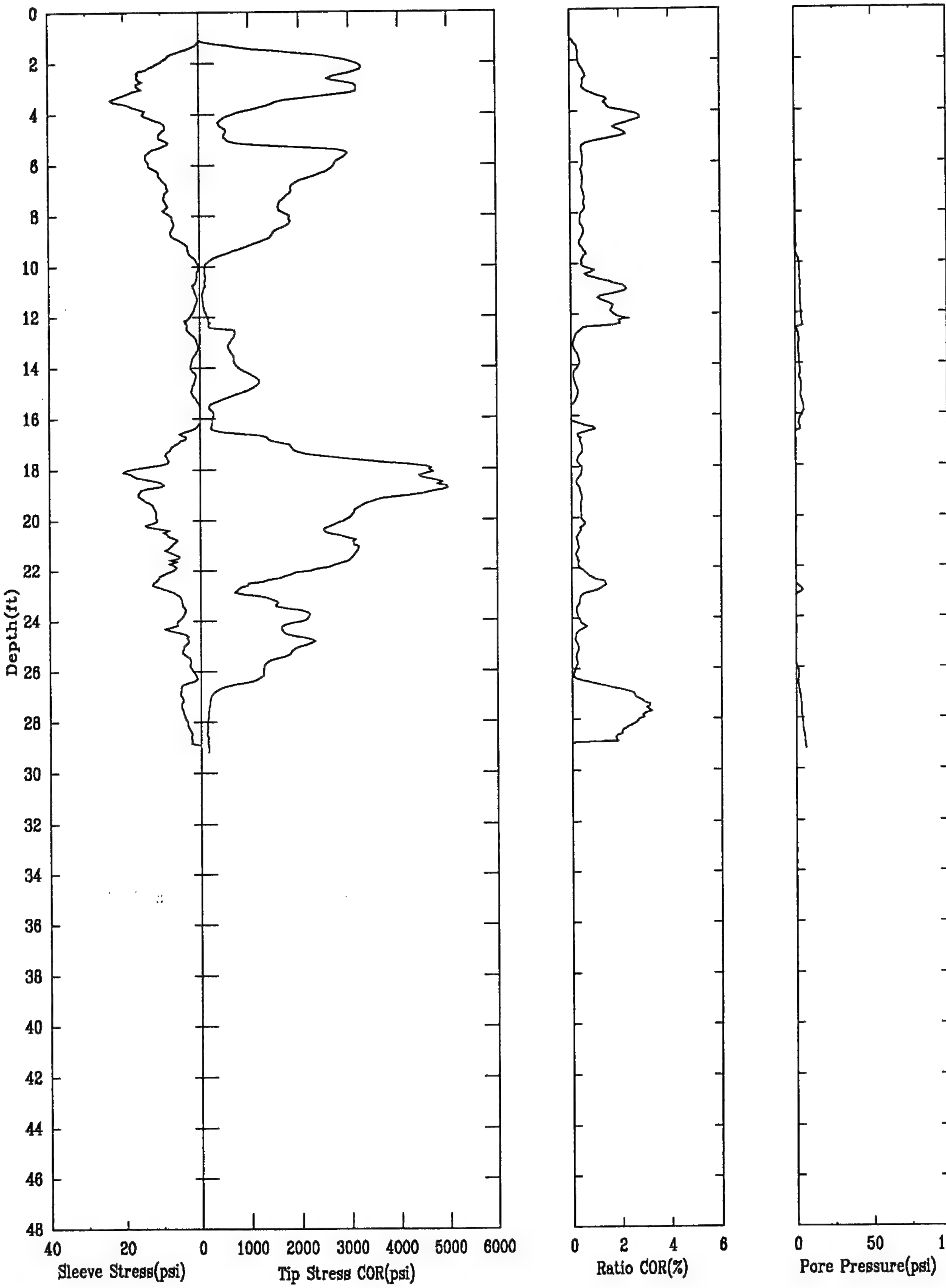


XYZ-CPT-18-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base

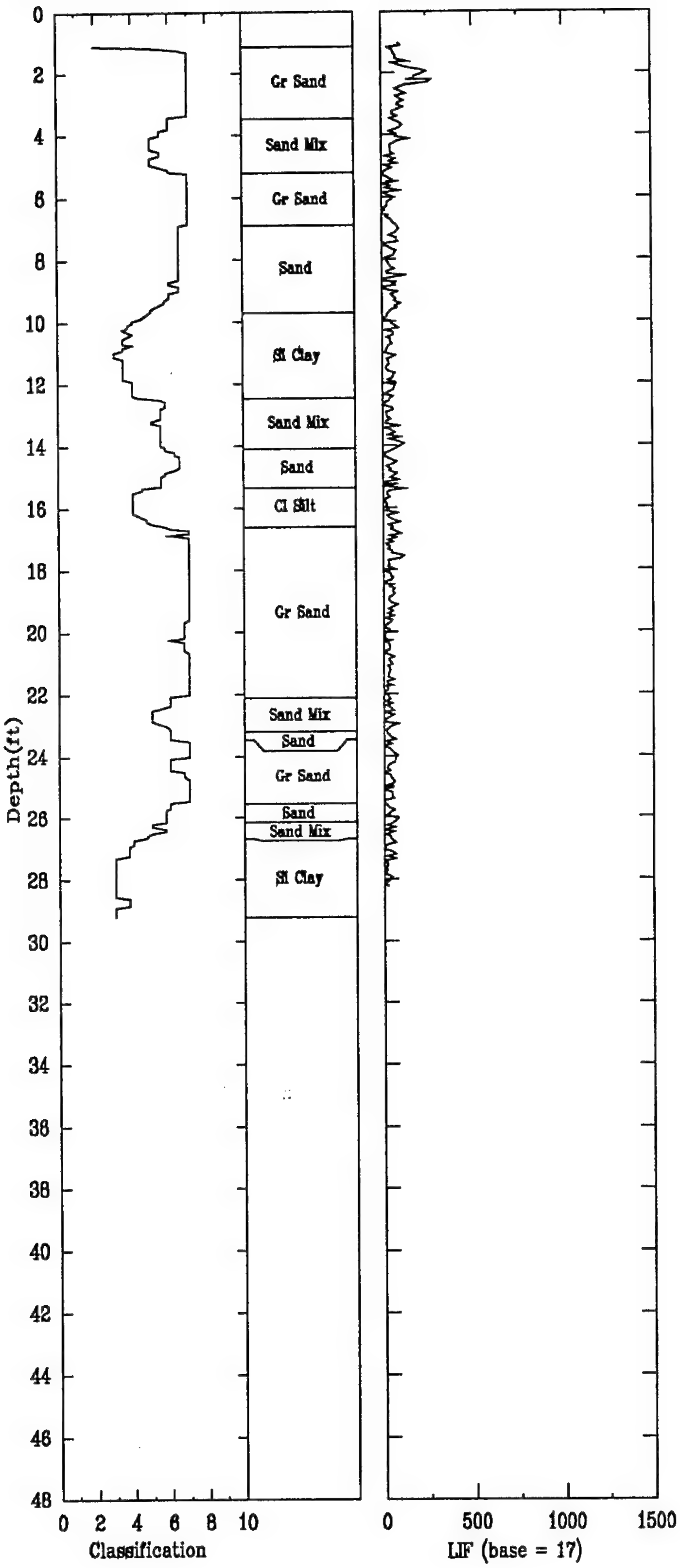


Dover Air Force Base



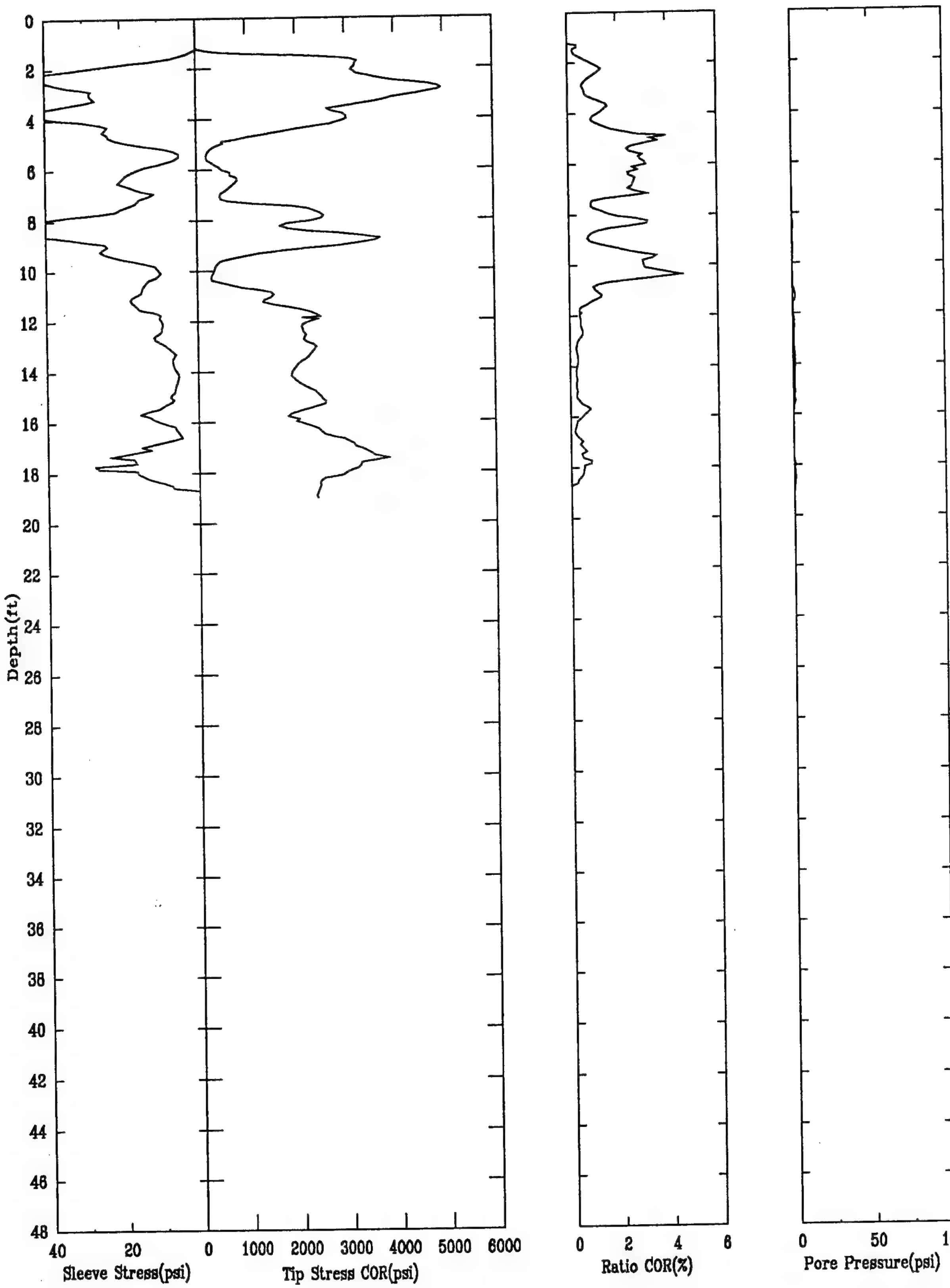
XYZ-CPT-19-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



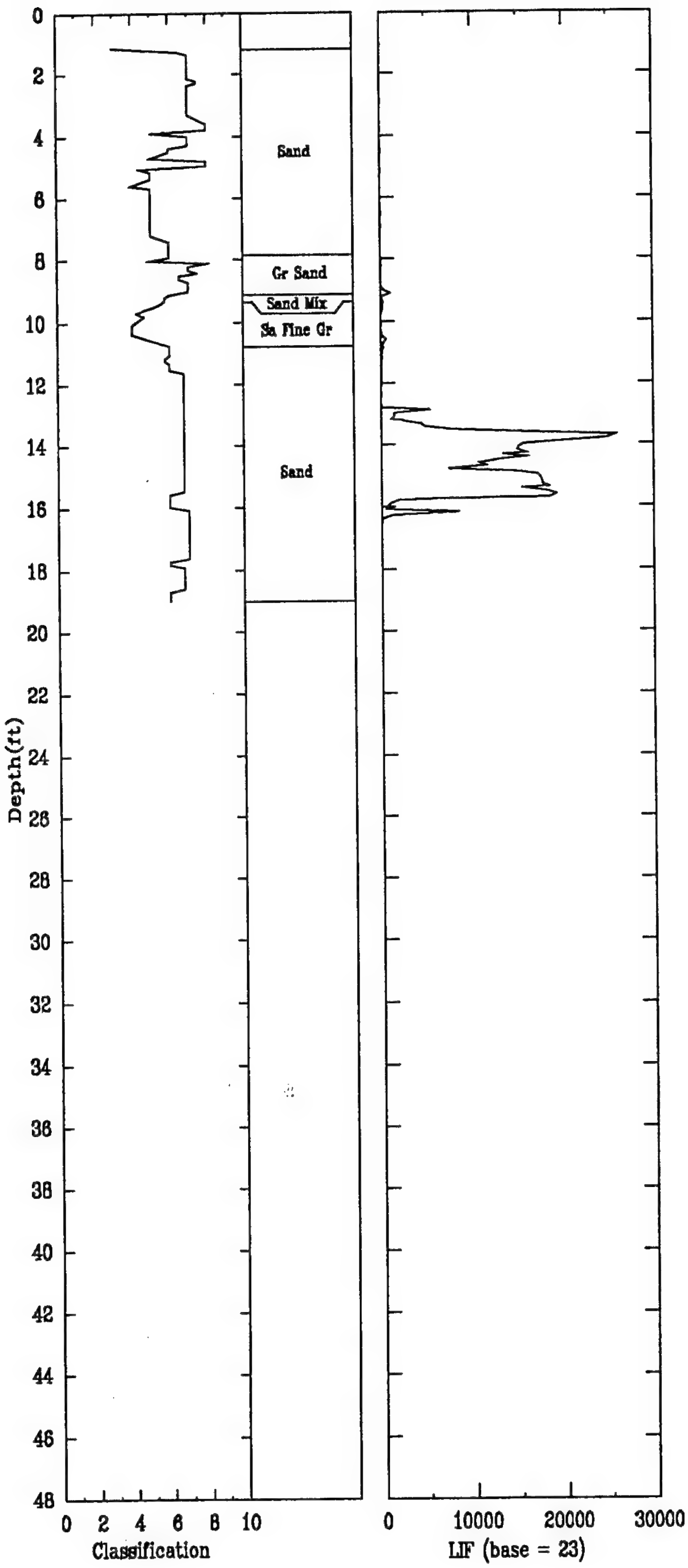
XYZ-CPT-20-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



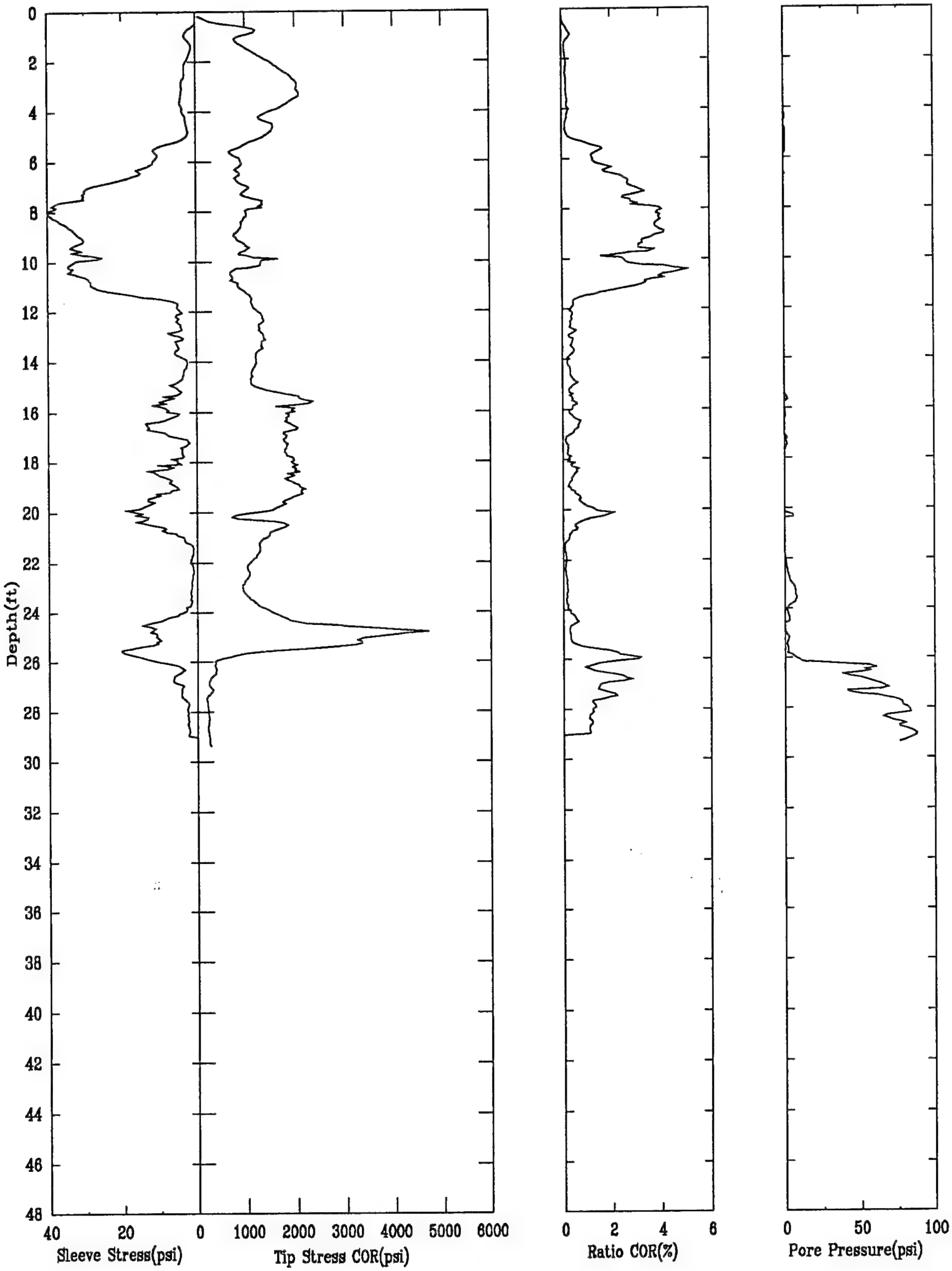
XYZ-CPT-20-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/14/94

Dover Air Force Base



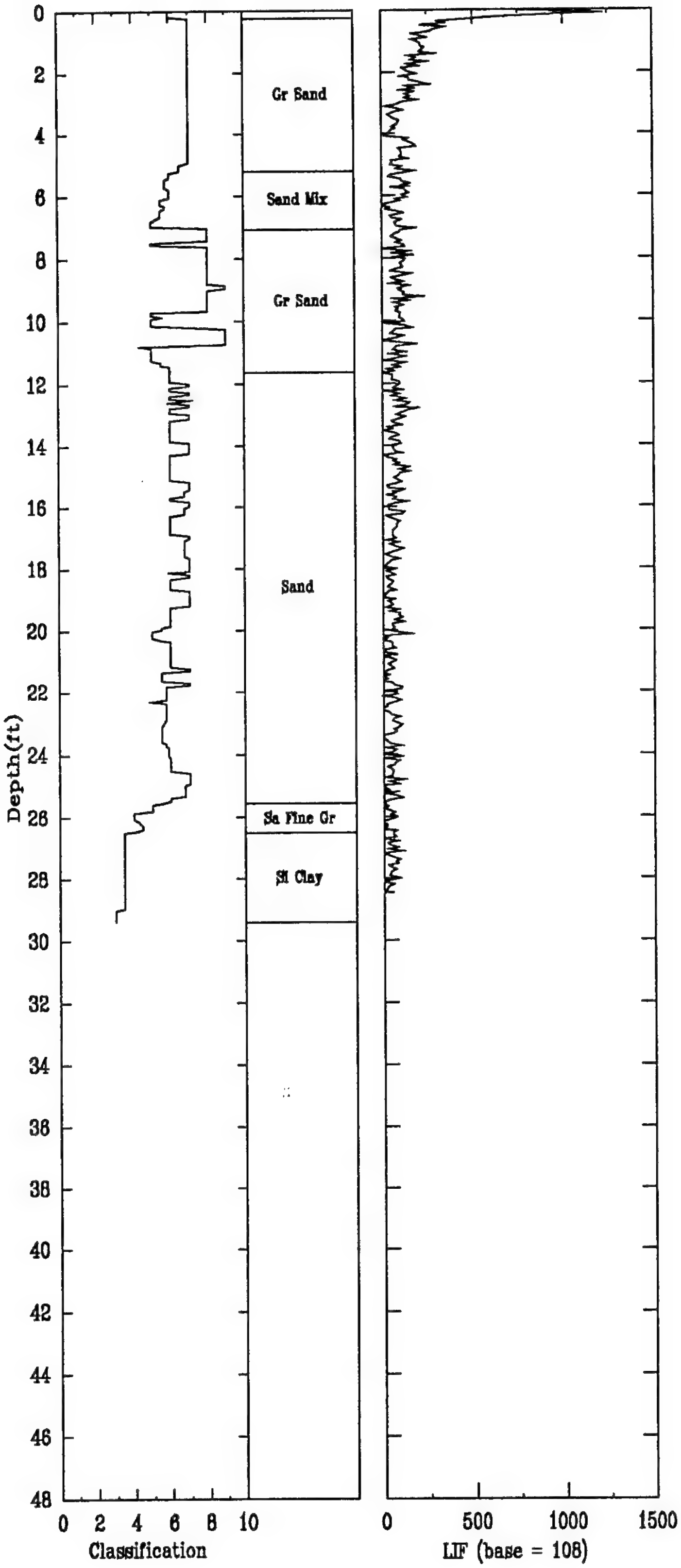
XYZ-CPT-21-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

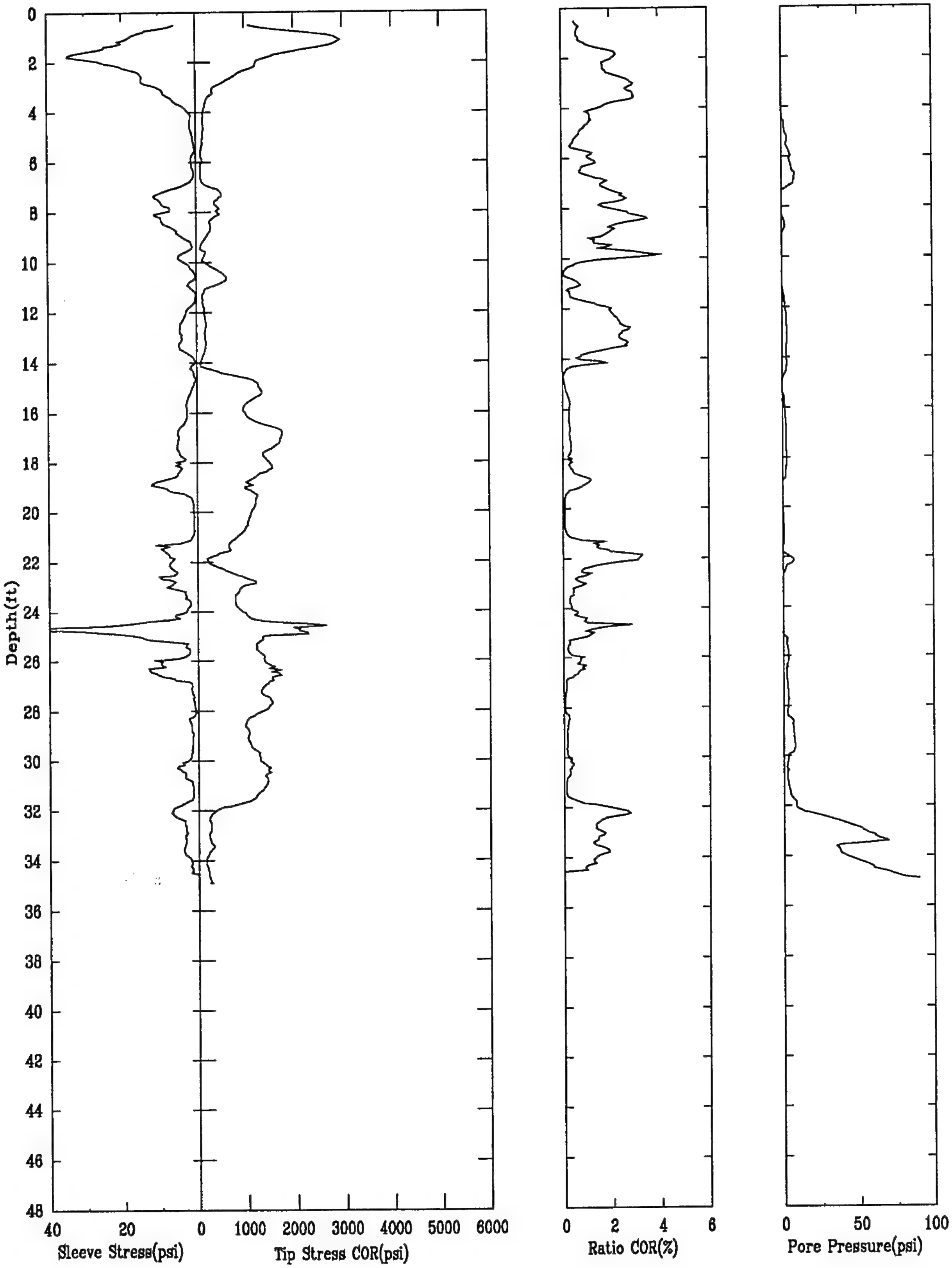


XYZ-CPT-21-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

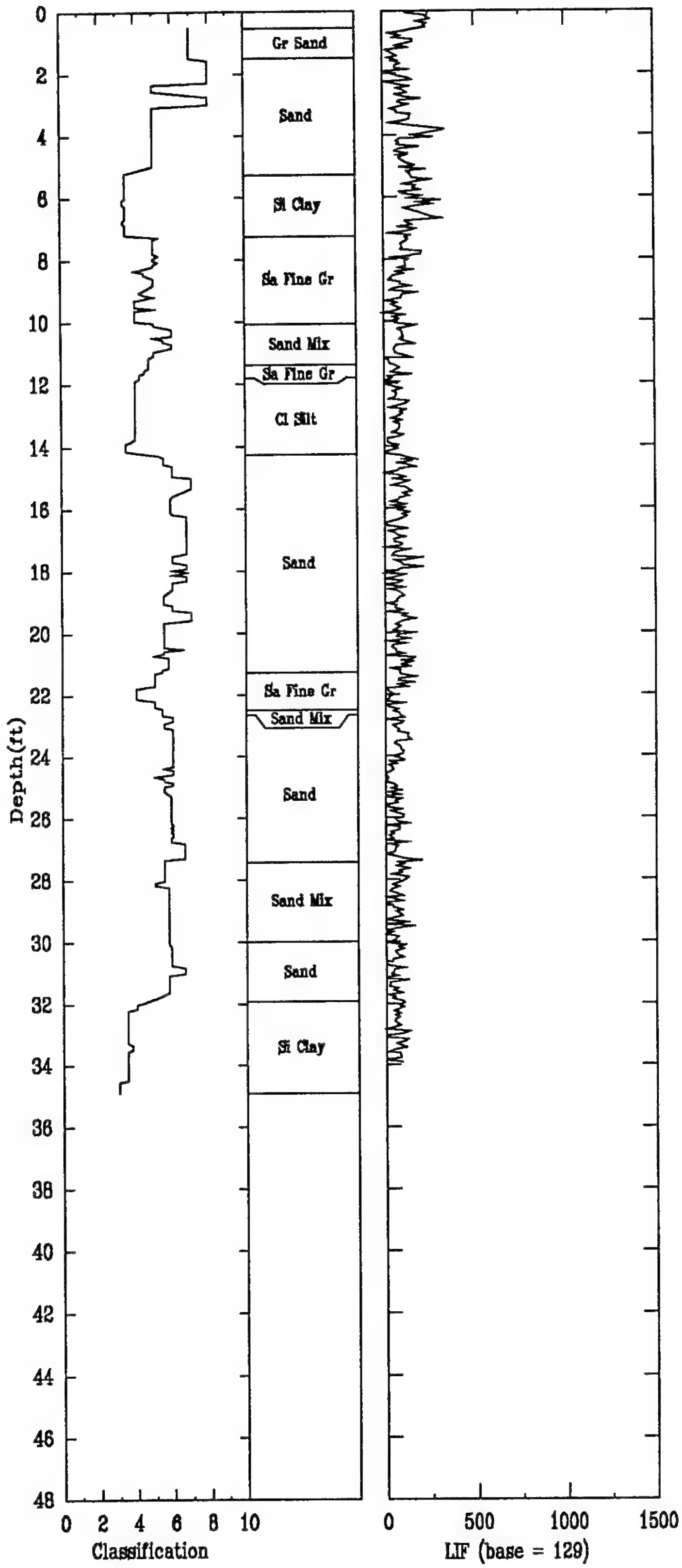


Dover Air Force Base



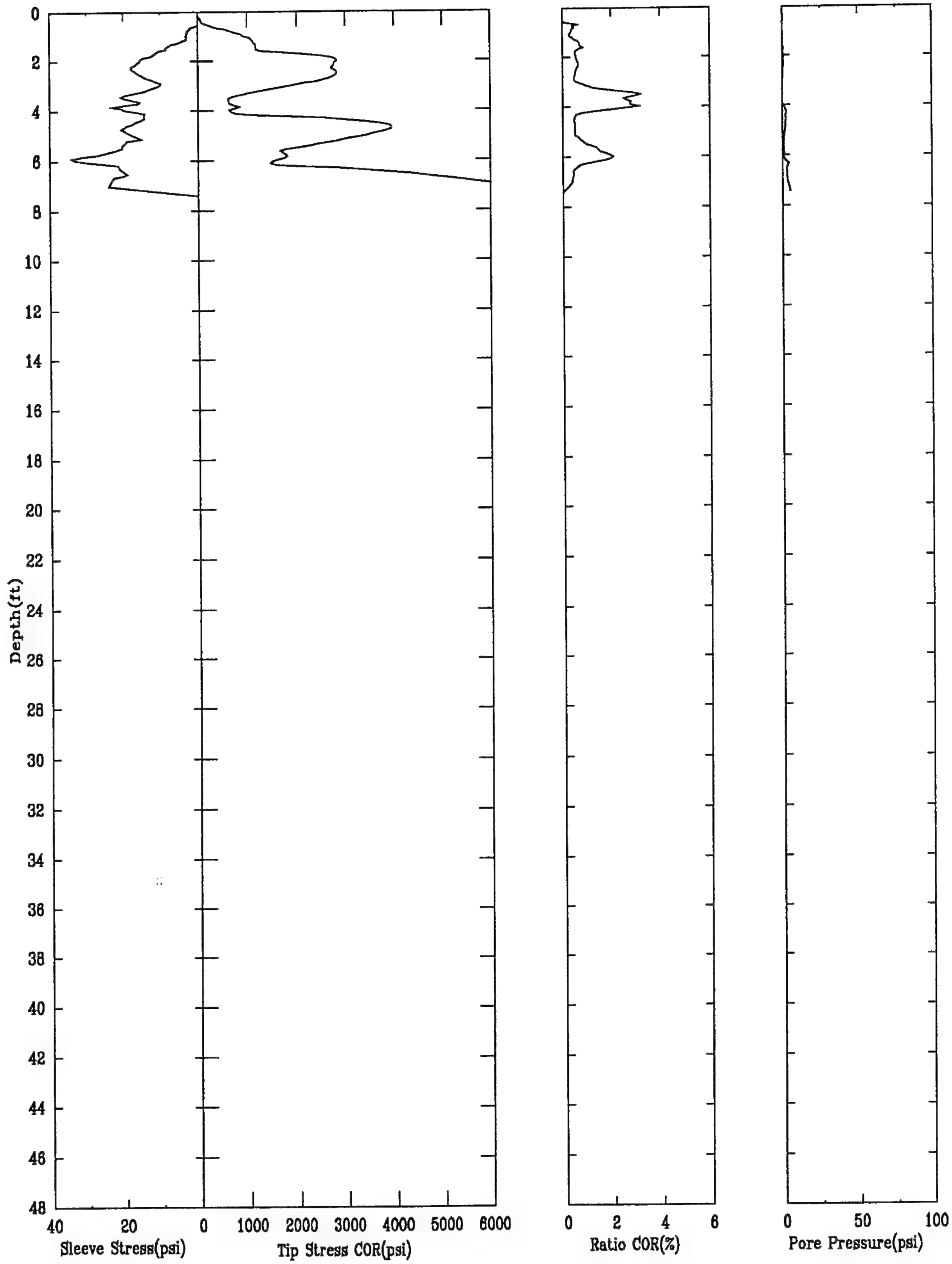
XYZ-CPT-22-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

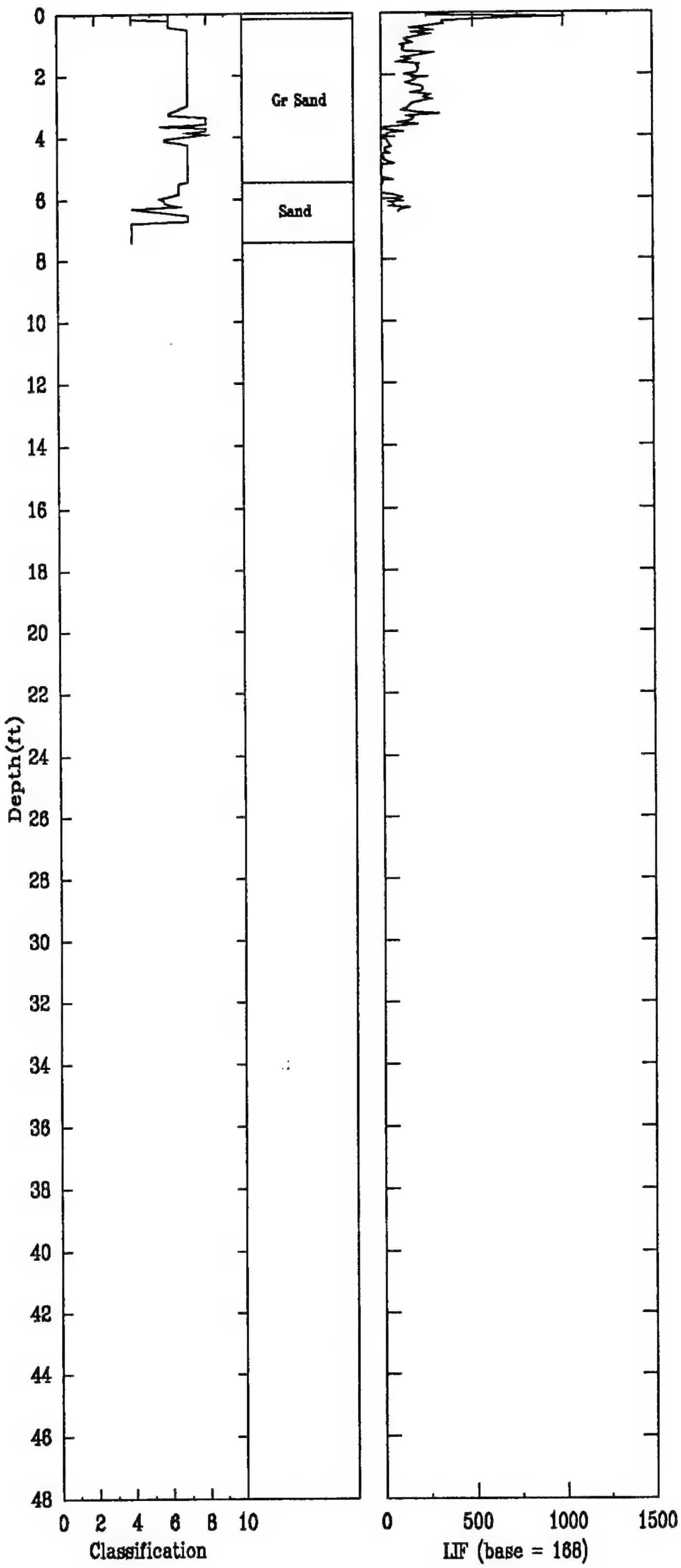


XYZ-CPT-23-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

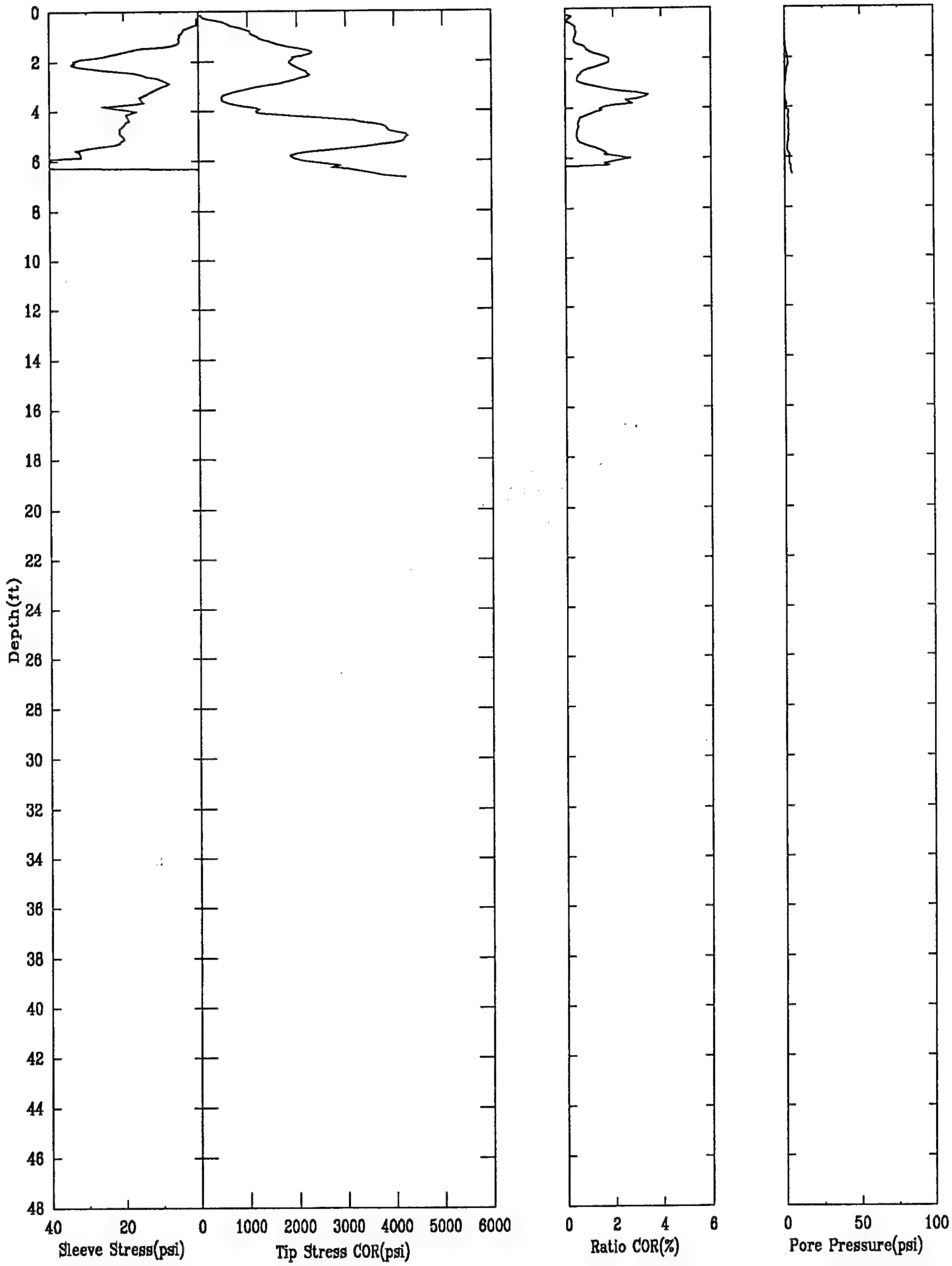


Dover Air Force Base



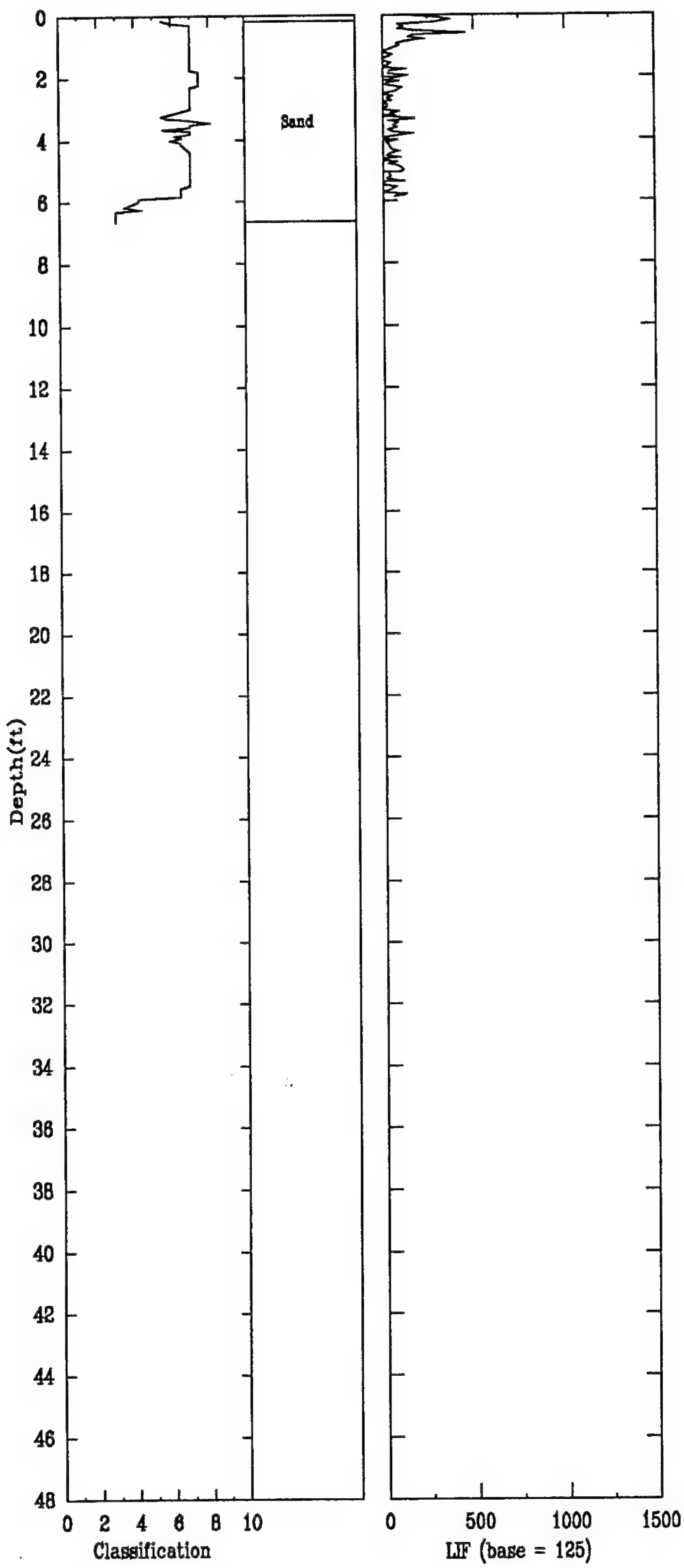
XYZ-CPT-23A-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base



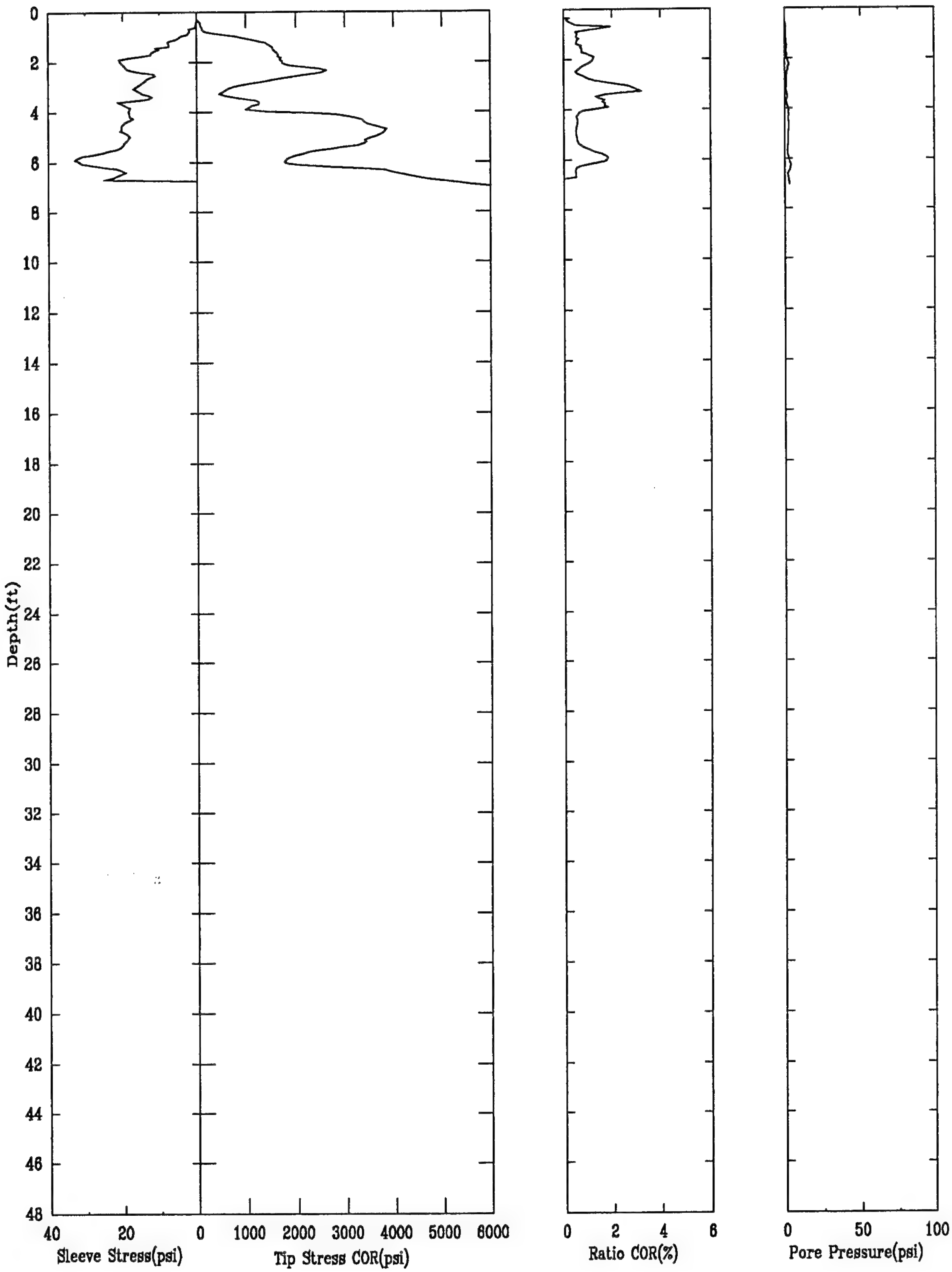
XYZ-CPT-23A-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

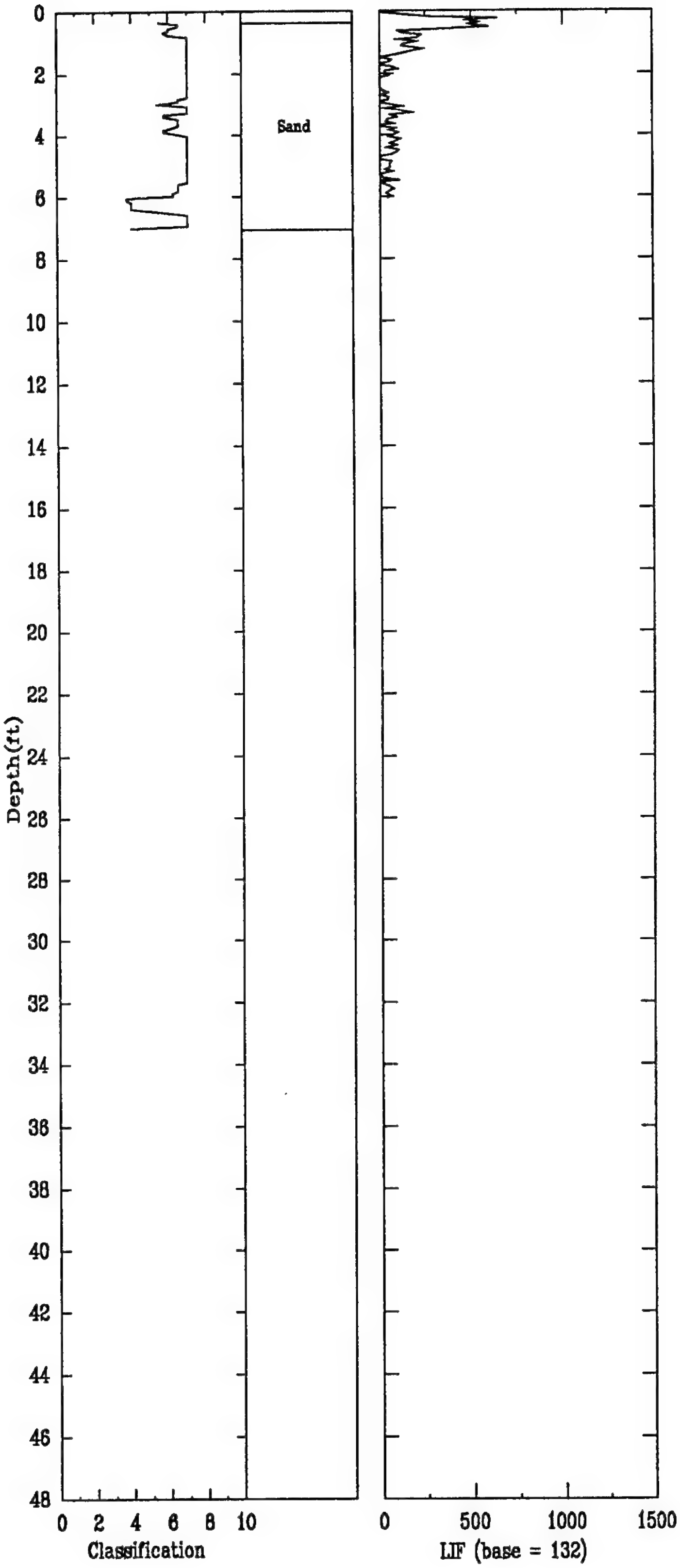


XYZ-CPT-23B-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

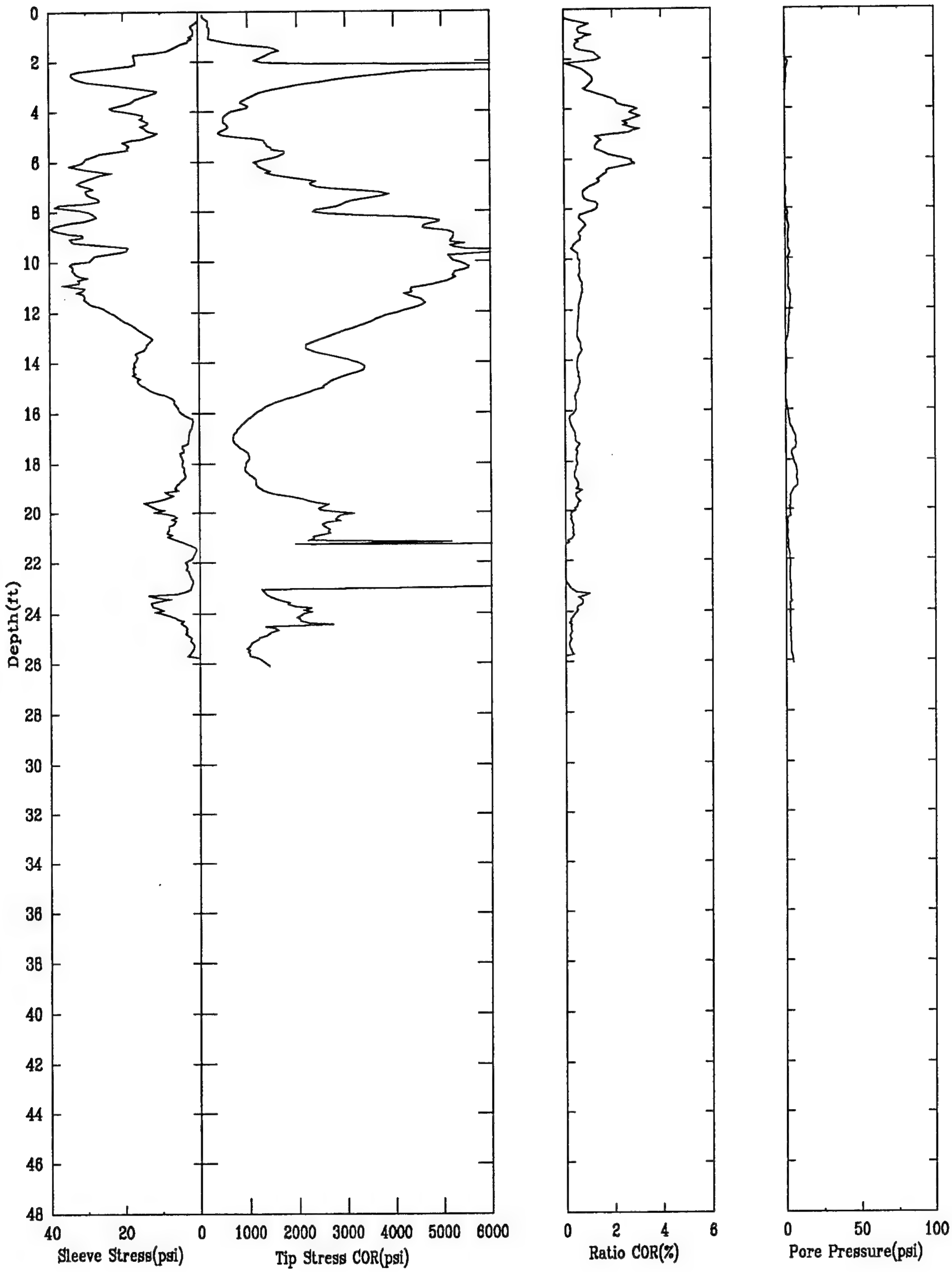


Dover Air Force Base



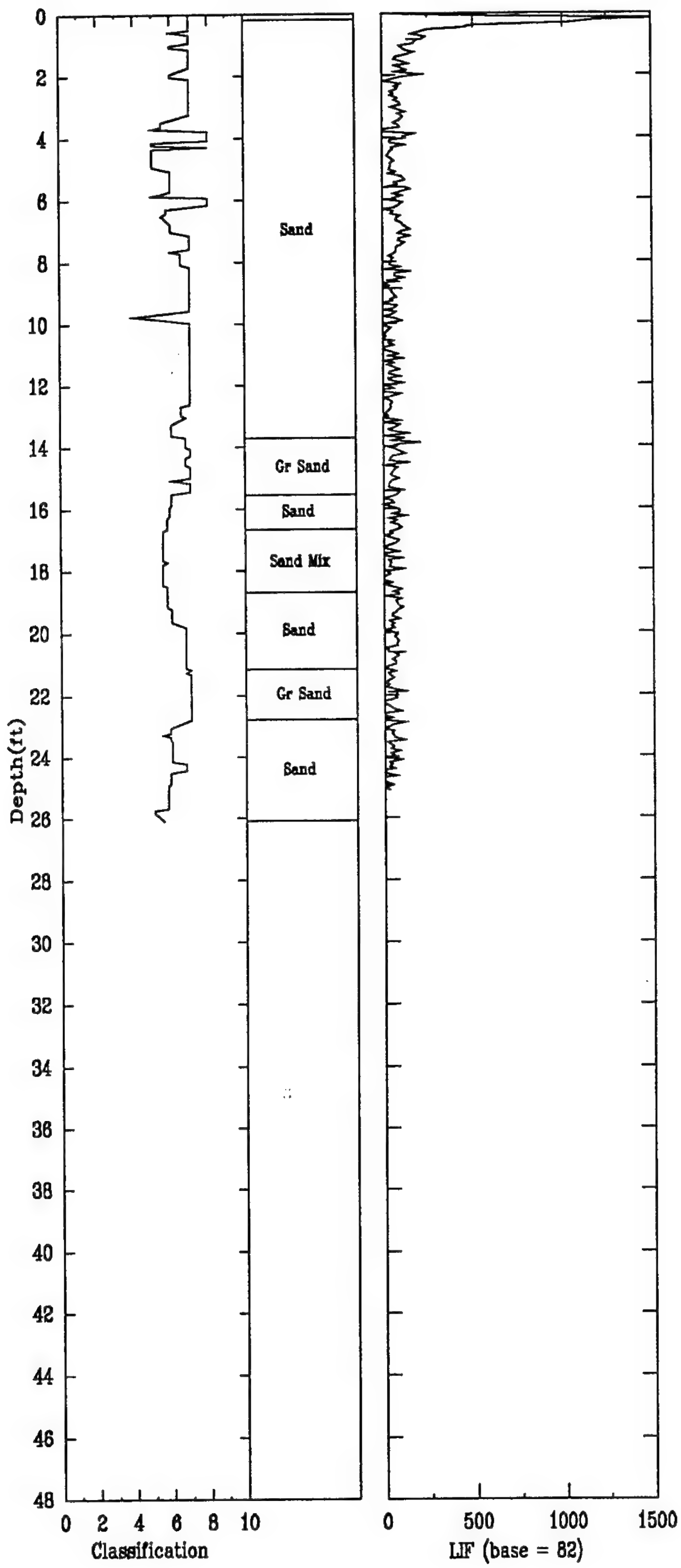
XYZ-CPT-24-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base



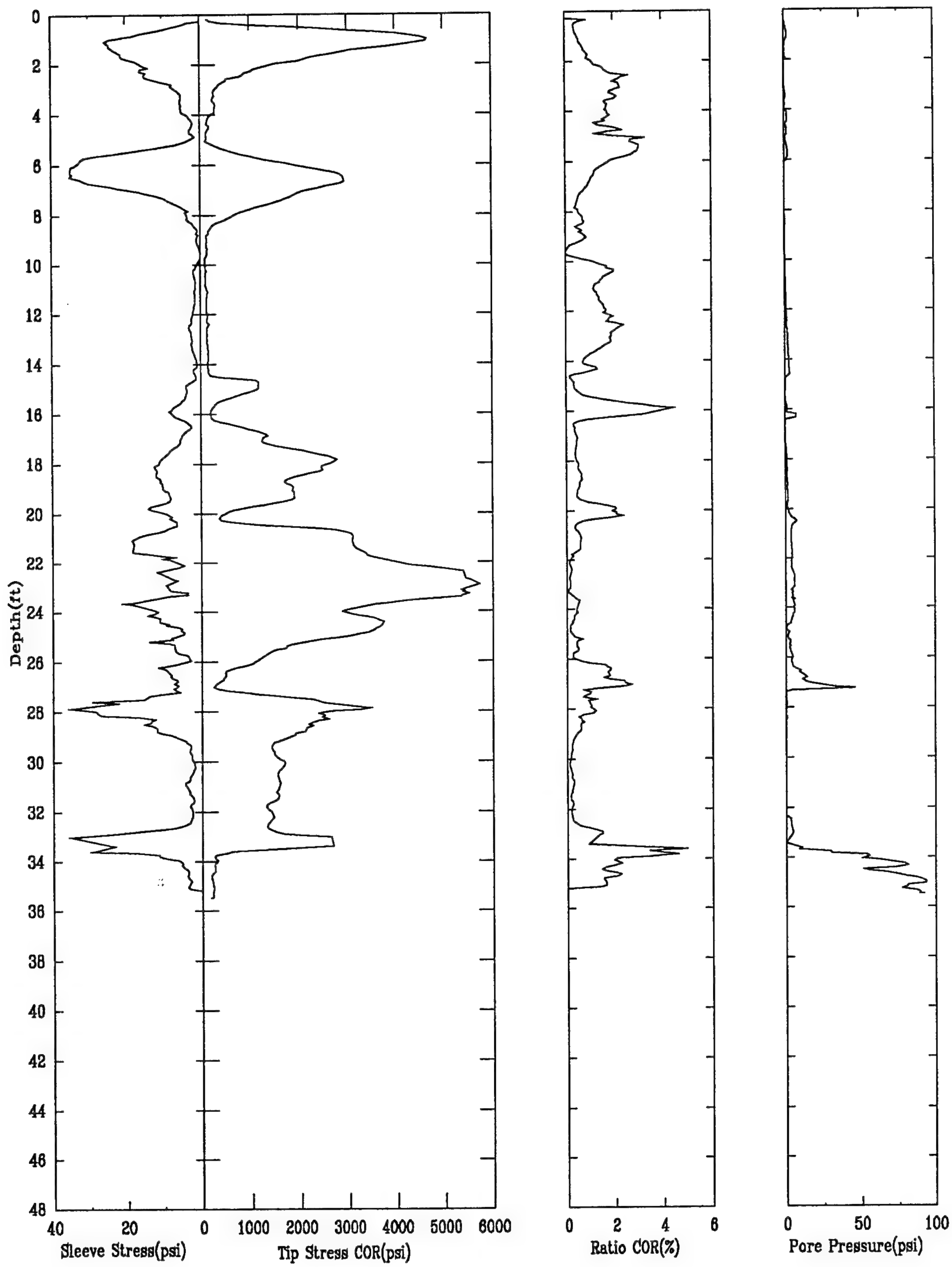
XYZ-CPT-24-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

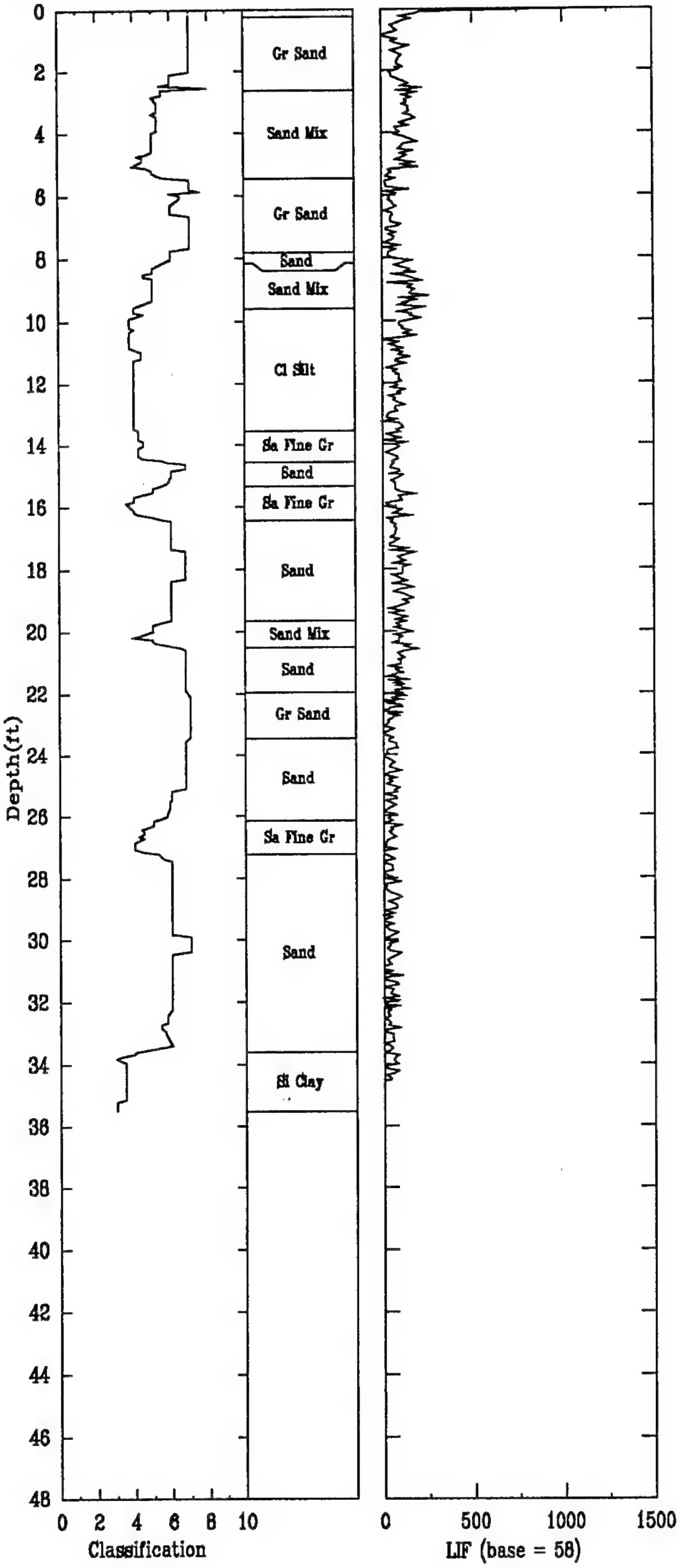


XYZ-CPT-26-LIF APPLIED RESEARCH ASSOCIATES, INC. 04/16/94

Dover Air Force Base

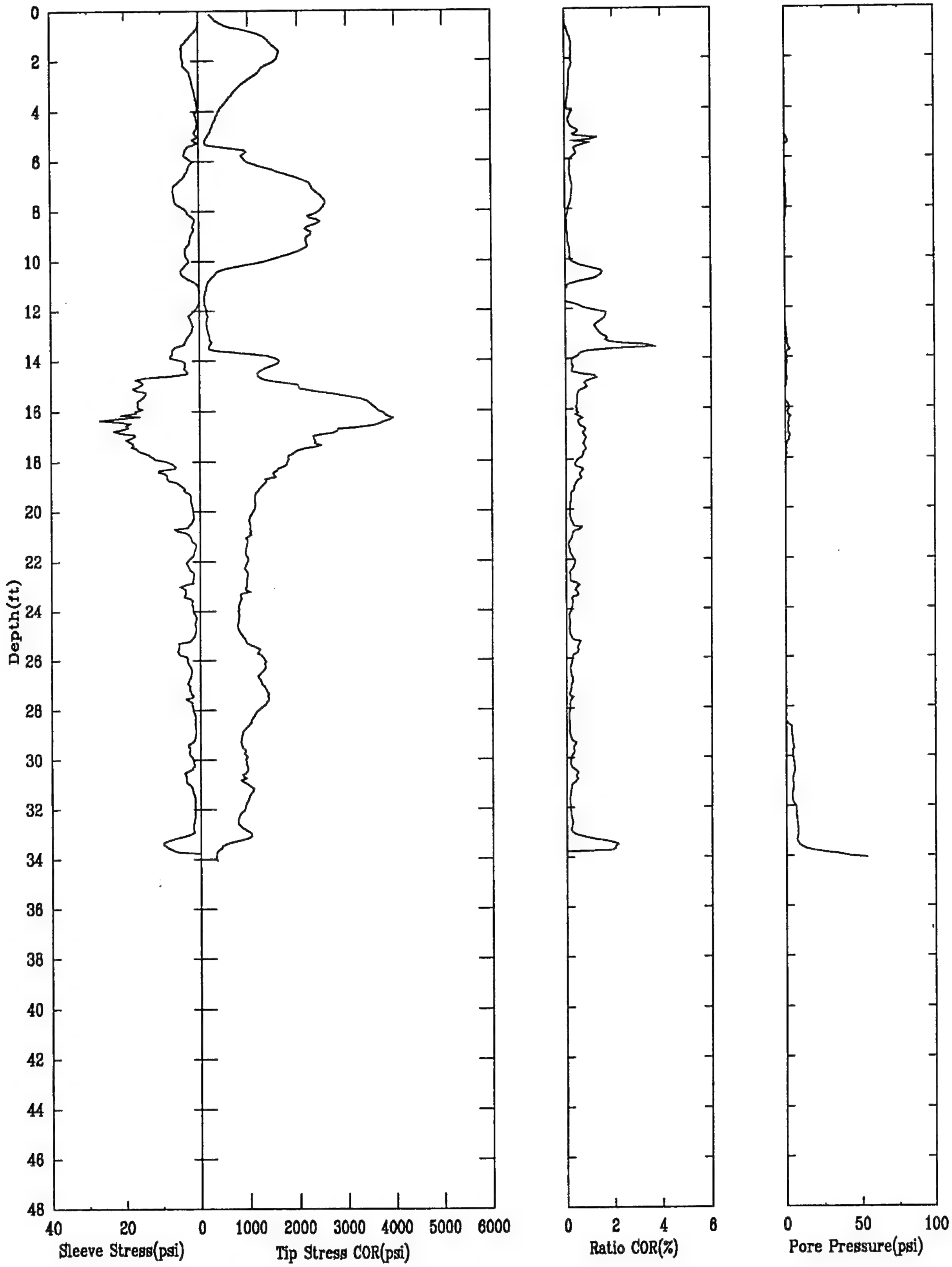


Dover Air Force Base



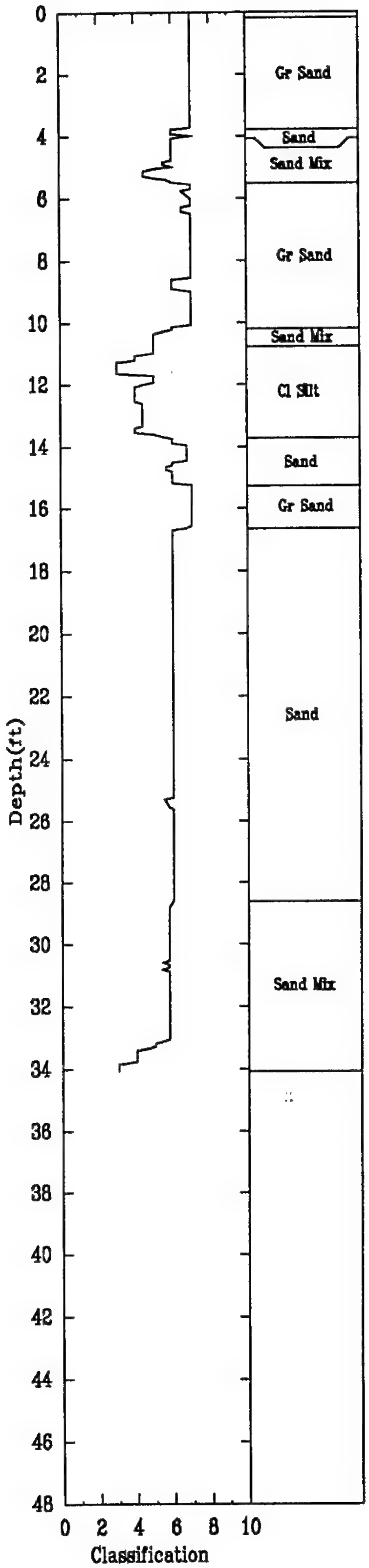
XYZ-CPT-27 APPLIED RESEARCH ASSOCIATES, INC. 04/18/94

Dover Air Force Base



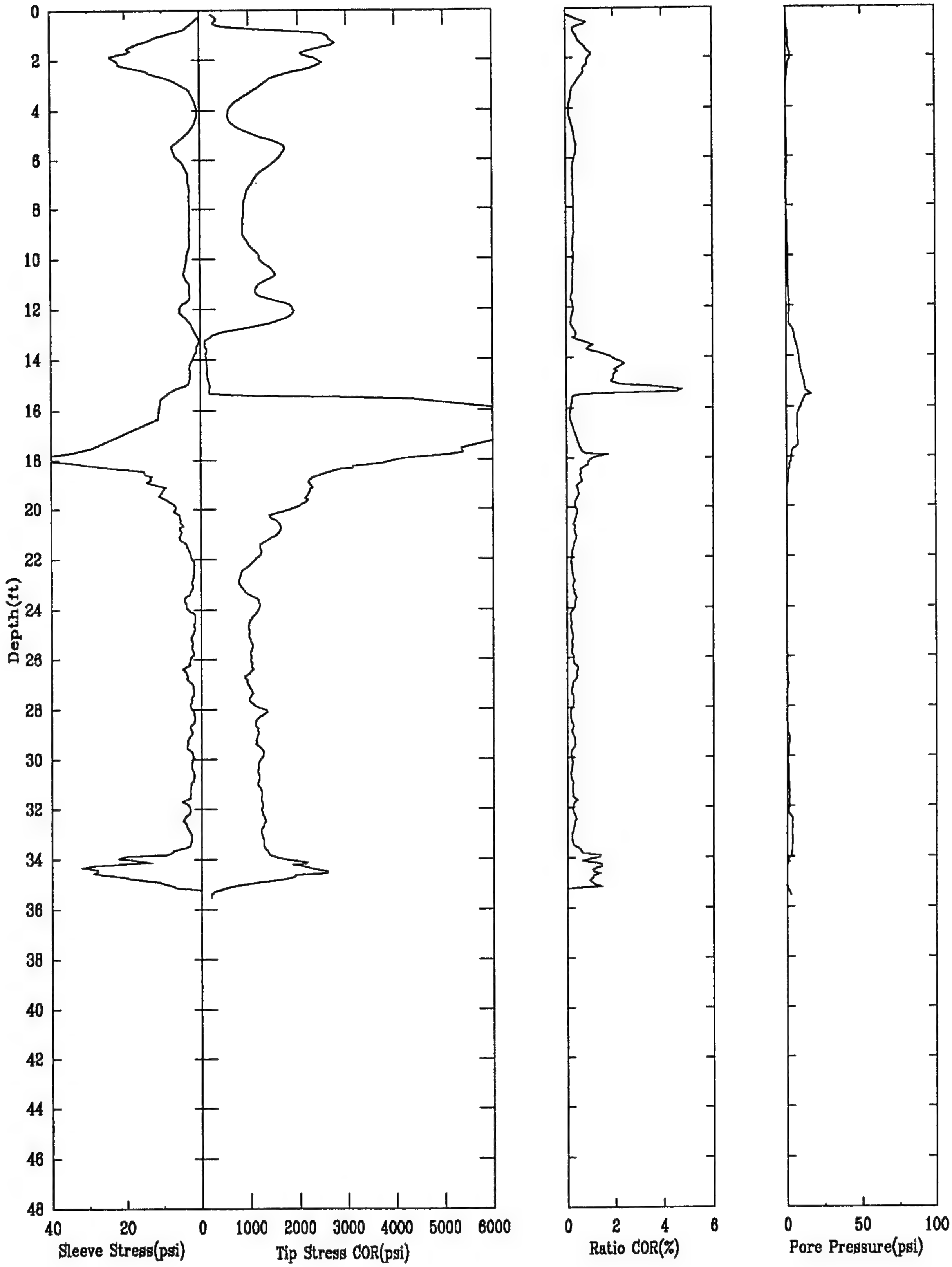
XYZ-CPT-27 APPLIED RESEARCH ASSOCIATES, INC. 04/18/94

Dover Air Force Base



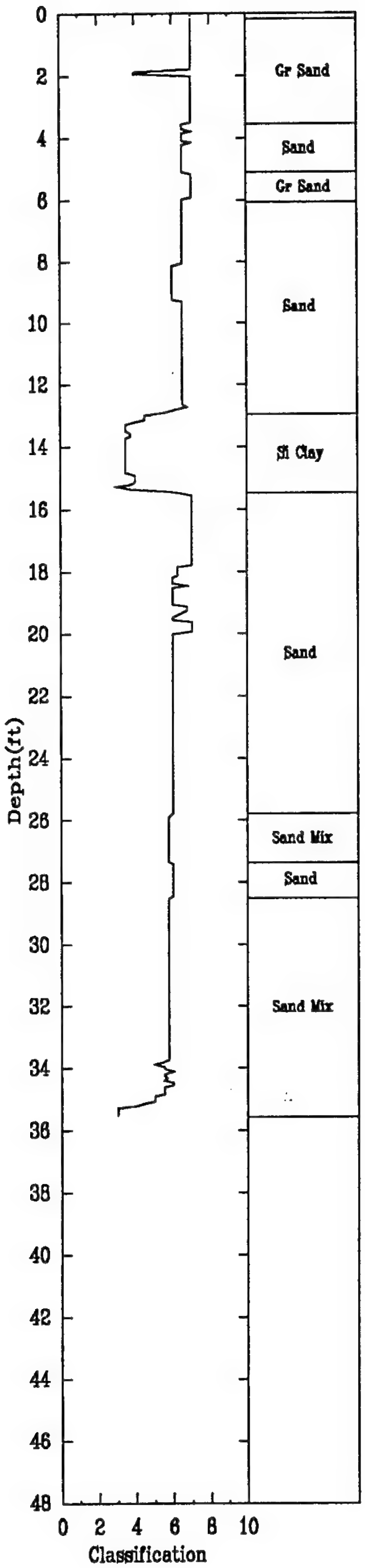
XYZ-CPT-28 APPLIED RESEARCH ASSOCIATES, INC. 04/18/94

Dover Air Force Base



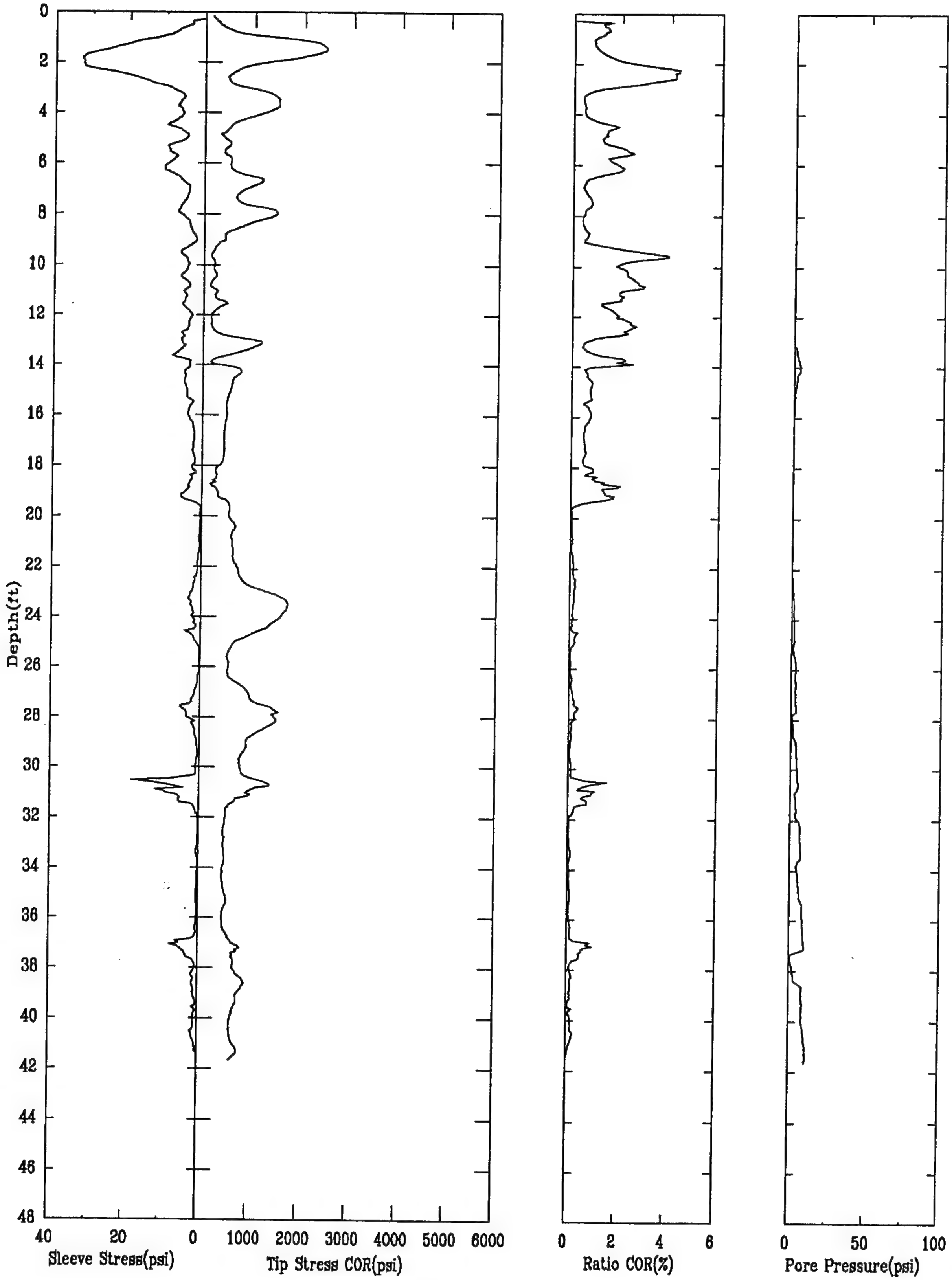
XYZ-CPT-28 APPLIED RESEARCH ASSOCIATES, INC. 04/18/94

Dover Air Force Base

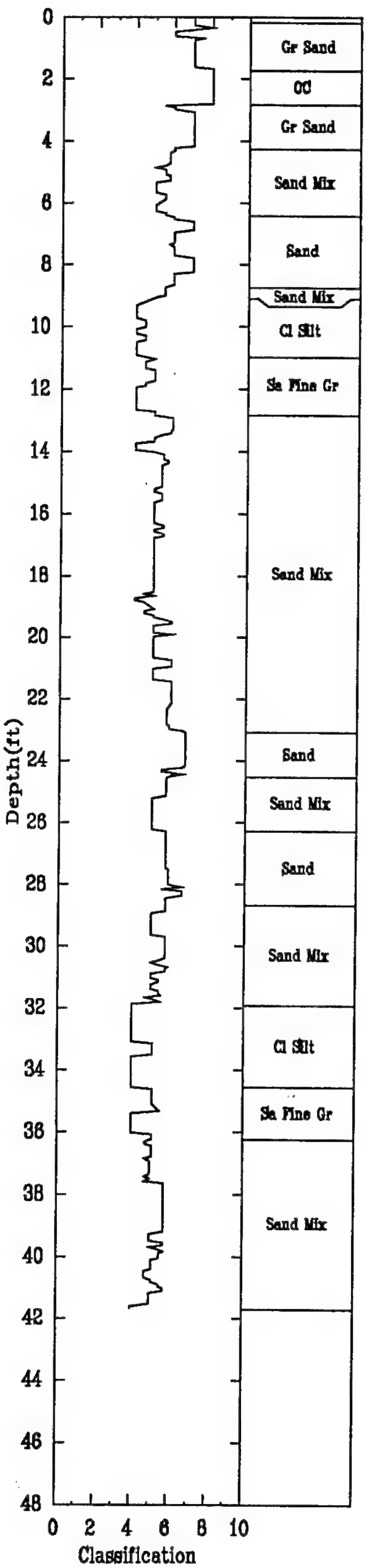


D7-CPT-01 APPLIED RESEARCH ASSOCIATES, INC. 04/19/94

Dover Air Force Base

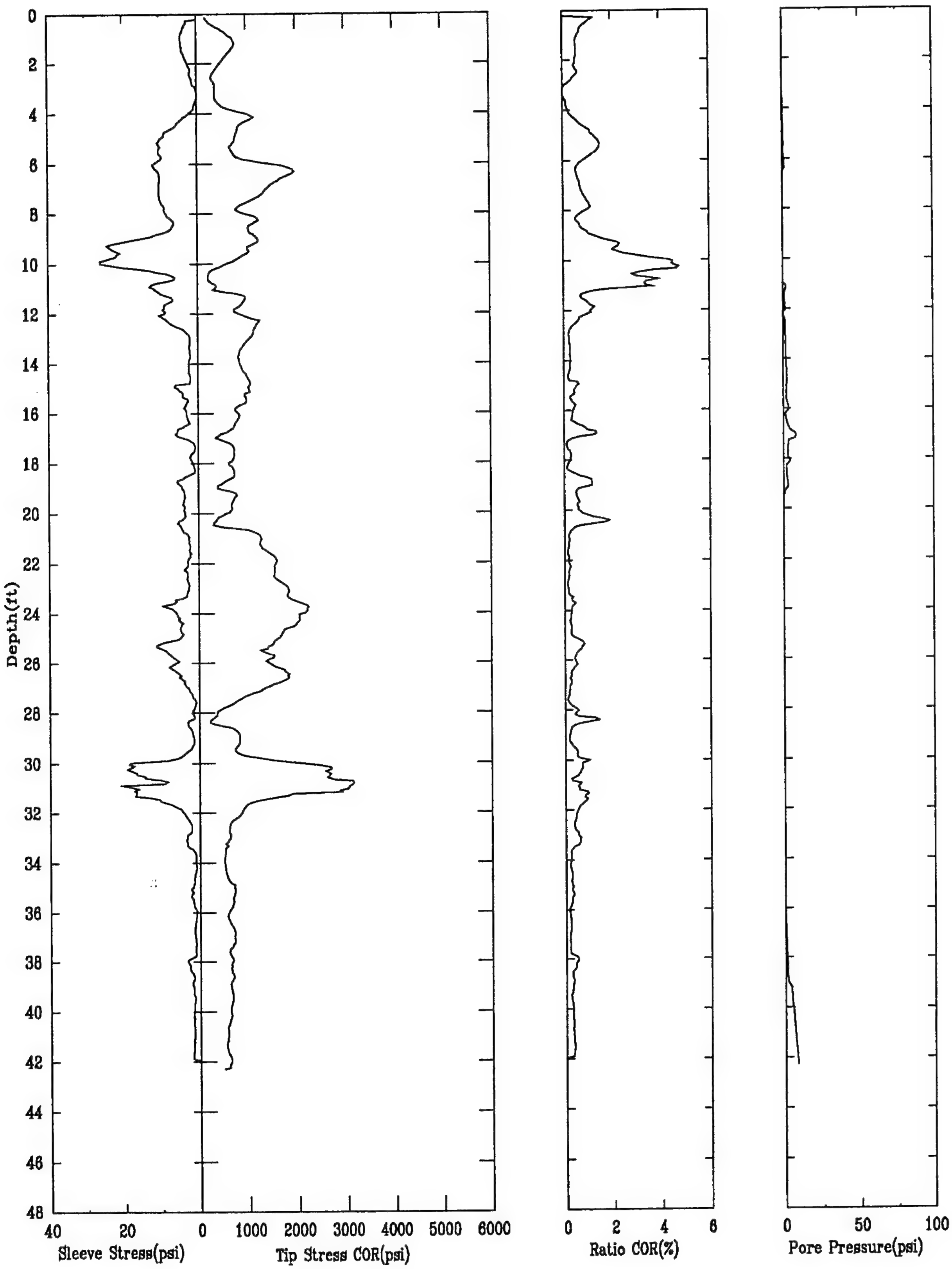


Dover Air Force Base



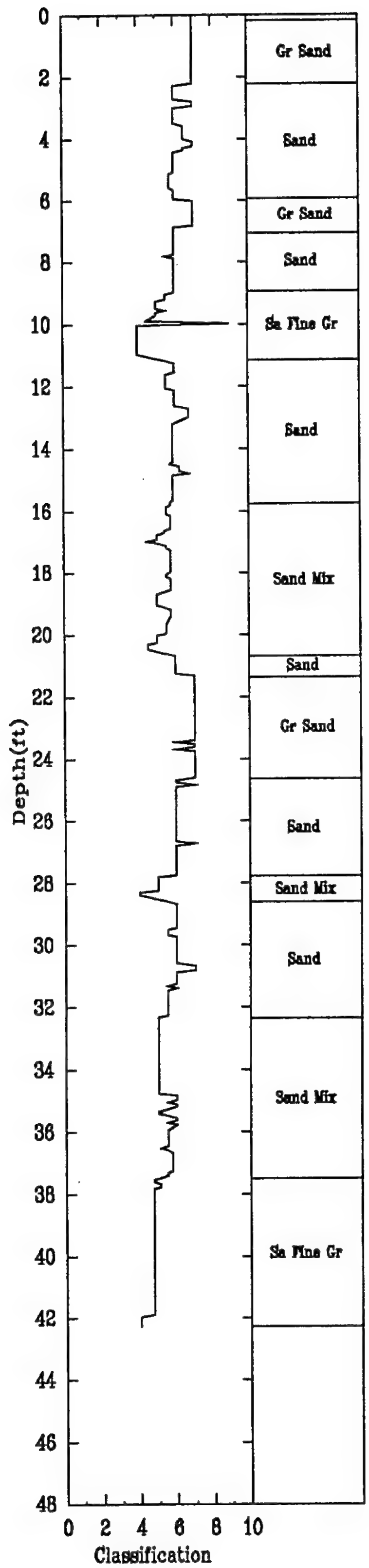
D7-CPT-02 APPLIED RESEARCH ASSOCIATES, INC. 04/19/94

Dover Air Force Base

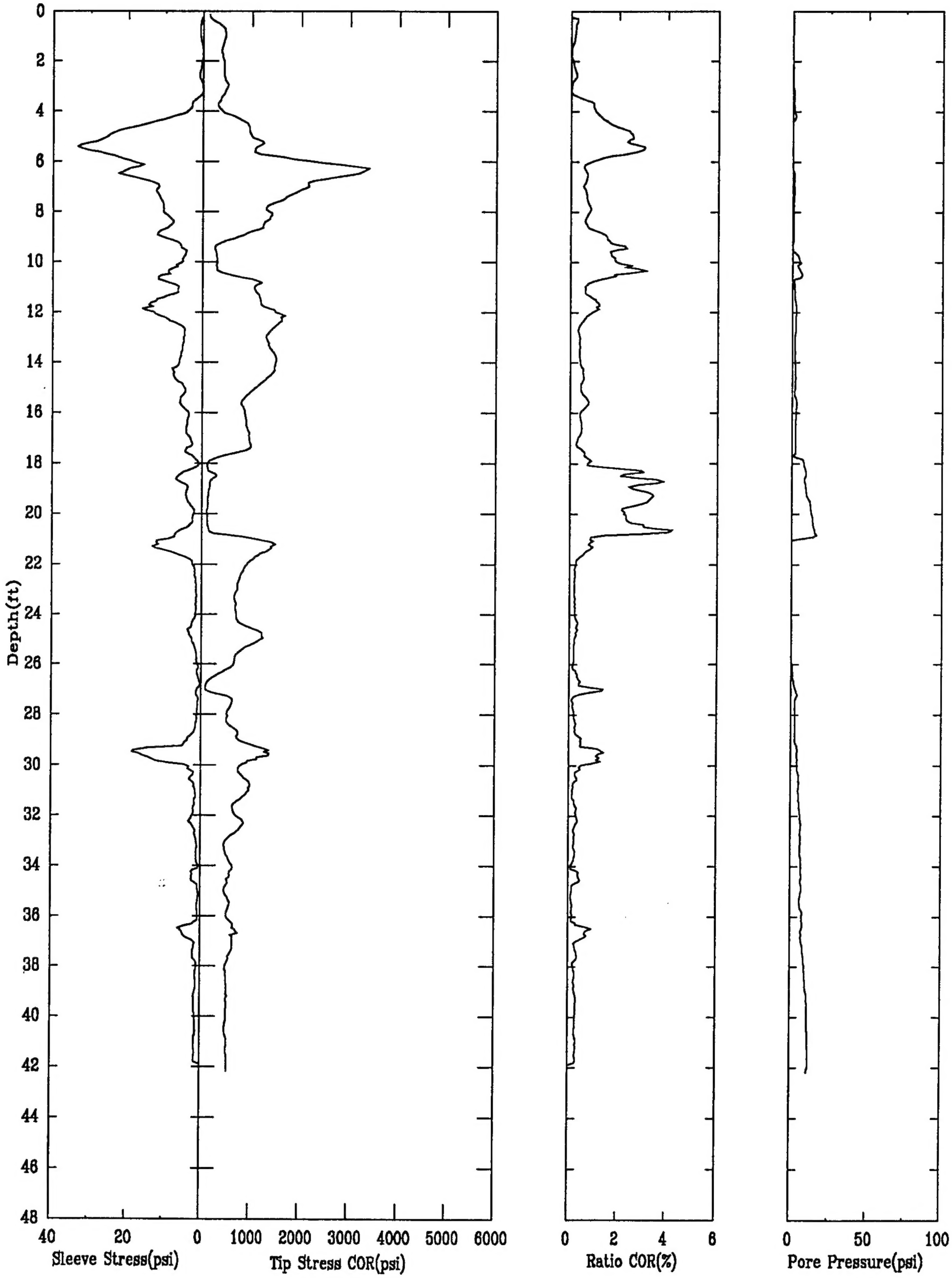


D7-CPT-02 APPLIED RESEARCH ASSOCIATES, INC. 04/19/94

Dover Air Force Base

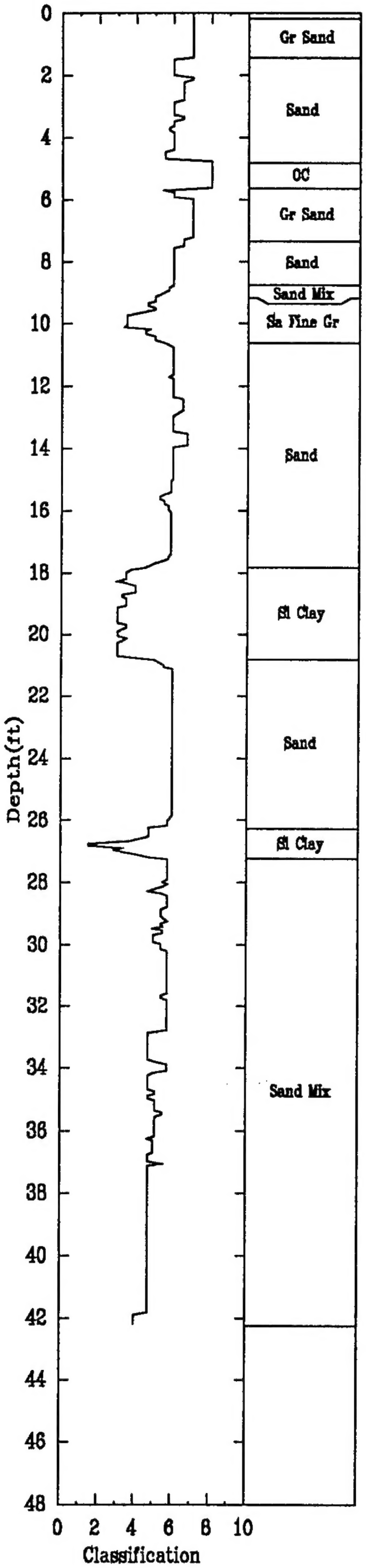


Dover Air Force Base

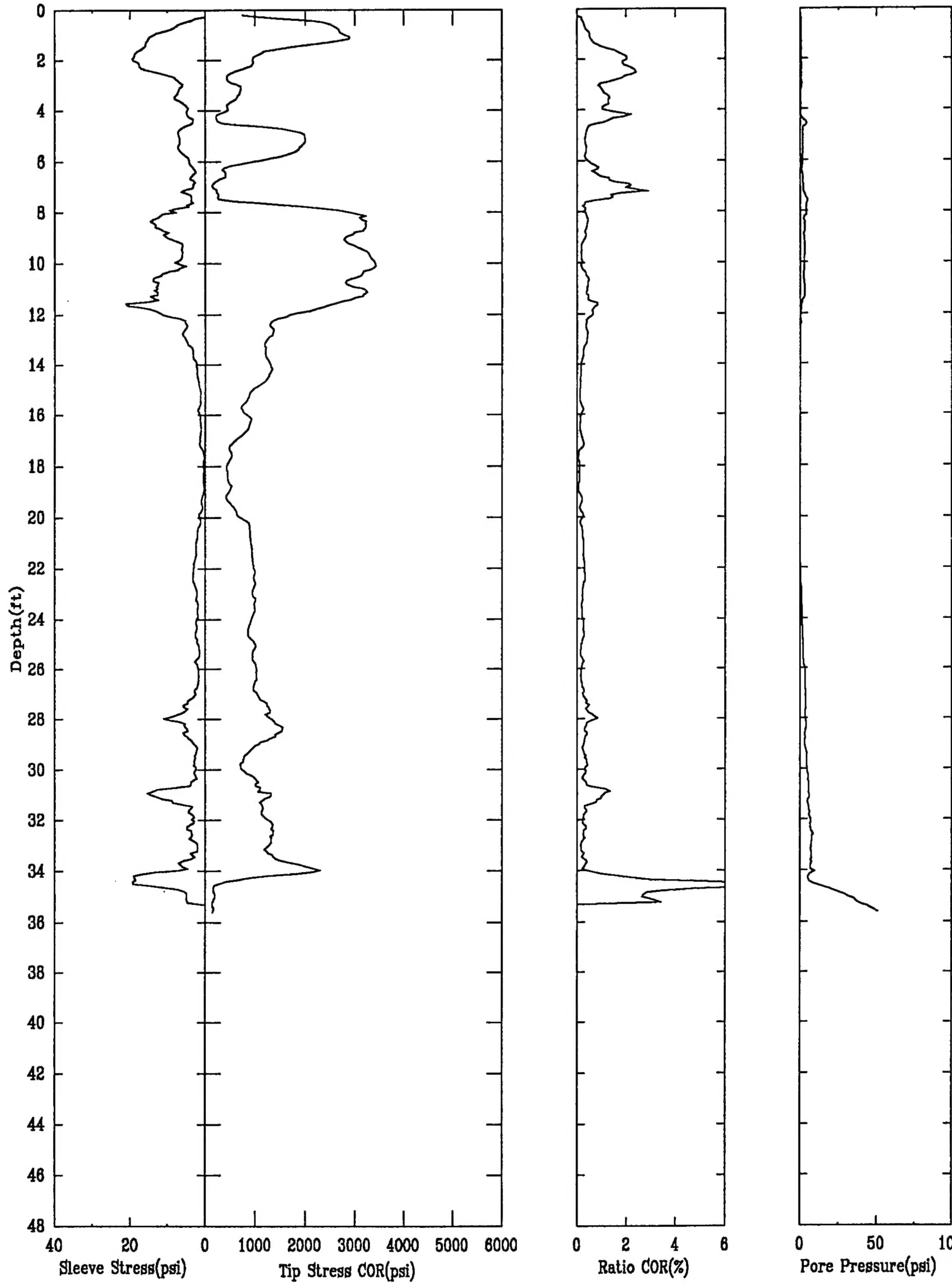


D7-CPT-03 APPLIED RESEARCH ASSOCIATES, INC. 04/19/94

Dover Air Force Base



Dover Air Force Base



XYZ-CPT-29 APPLIED RESEARCH ASSOCIATES, INC. 04/19/94

Dover Air Force Base